DRAFT FEASIBILITY STUDY REPORT
SAN JACINTO WASTE PITS SUPERFUND SITE

Prepared for

McGinnes Industrial Maintenance Corporation and

International Paper Company

Prepared by

Anchor QEA, LLC

614 Magnolia Avenue

Ocean Springs, Mississippi 39564

August 2013

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LIST OF ACRONYMS AND ABBREVIATIONS

2H:1V	2 horizontal to 1 vertical
3H:1V	3 horizontal to 1 vertical
5H:1V	5 horizontal to 1 vertical
AOC	Agreement and Order on Consent
ARAR	Applicable or Relevant and Appropriate Requirements
BERA	Baseline Ecological Risk Assessment
BHHRA	Baseline Human Health Risk Assessment
BMP	Best Management Practices
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm/year	centimeters per year
COC	chemical of concern
COPC	chemical of potential concern
CSM	Conceptual Site Model
CWA	Clean Water Act
cy	cubic yard
EAM	Exposure Assessment Memorandum
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FS	Feasibility Study
GLO	Texas General Land Office
GRA	General Response Action
HSC	Houston Ship Channel
I-10	Interstate Highway 10
IC	Institutional Controls
IP	International Paper Company
MIMC	McGinnes Industrial Maintenance Corporation
mm/year	millimeters per year
MNR	Monitored Natural Recovery

MSL	mean sea level
NCP	National Contingency Plan
ng/kg	nanograms per kilogram
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRHP	National Register of Historic Places
NSR	net sedimentation rate
OMM	Operations, Monitoring, and Maintenance
PCB	polychlorinated biphenyl
PCL	Protective Concentration Level
PM	particulate matter
$PM_{2.5}$	fine partical particulate matter
PRG	preliminary remedial goals
PSCR	Preliminary Site Characterization Report
RACR	Removal Action Completion Report
RALs	remedial action levels
RAM	Remedial Alternatives Memorandum
RAO	Remedial Action Objective
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
ROD	Record of Decision
ROW	right-of-way
S/S	solidification/stabilization
Site	San Jacinto River Waste Pits Superfund Site
SJRF	San Jacinto River Fleet
SJRWP	San Jacinto River Waste Pits
SMA	sediment management area
SPME	solid phase microextraction
SWAC	surface-weighted average concentration
SWPPP	Storm Water Pollution Prevention Plan
TBC	to-be-considered

TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TCDF	2,3,7,8-tetrachlorodibenzofuran
TCEQ	Texas Commission on Environmental Quality
TCRA	time critical removal action
TEQ	toxic equivalents
$TEQ_{DF,M}$	TEQ concentration calculated for dioxin and furan congeners using toxicity equivalency factors for mammals
TES	threatened and endangered species
TMV	toxicity, mobility, or volume
TPDES	Texas Pollutant Discharge Elimination System
TxDOT	Texas Department of Transportation
UAO	Unilateral Administrative Order
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Services

EXECUTIVE SUMMARY

This report presents the Feasibility Study (FS) for the San Jacinto River Waste Pits (SJRWP) Superfund Site (Site) in Harris County Texas, and was prepared as a companion to the related Remedial Investigation (RI) Report (Integral and Anchor QEA 2013a). Both this FS Report and the RI Report were prepared on behalf of McGinnes Industrial Maintenance Corporation (MIMC) and International Paper Company (IP) and in response to a Unilateral Administrative Order (UAO) issued by the U.S. Environmental Protection Agency (USEPA), Docket No. 06-03-10. The SJRWP Site was added to the National Priorities List (NPL) under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) in 2008. The Preliminary Perimeter, designated by USEPA in the UAO for purposes of the RI/FS investigation required by the UAO (USEPA's Preliminary Site Perimeter), encompasses several impoundments, built in the mid-1960s for disposal of paper mill wastes, and surrounding in-water and upland areas. The impoundments are on the western side of the San Jacinto River, in Harris County, Texas, north and south of Interstate Highway 10 (I-10).

A time critical removal action (TCRA) was implemented to stabilize materials within the impoundments located north of I-10 (the TCRA Site). The TCRA included construction of an armored cap (together with underlying geotextile and geomembrane layers), and installation of engineering controls around the perimeter of the TCRA Site, including warning signs and fencing. The TCRA has been effective in abating releases of materials from the TCRA Site and is currently under an ongoing inspection and maintenance program in accordance with a USEPA approved Operations, Monitoring, and Maintenance (OMM) plan (Appendix N of the RACR, Anchor QEA 2012a).

The RI Report prepared in response to the UAO identified protective concentration levels (PCLs) for soil and sediment, potentially applicable to various areas within the USEPA's Preliminary Site Perimeter consistent with reasonably anticipated futures uses. This FS Report uses these PCLs to develop a range of remedial alternatives addressing the impoundments both north and south of I-10, and to evaluate those alternatives relative to the CERCLA FS criteria described in the Code of Federal Regulations (CFR), Title 40, Part 300.430(e)(9). The alternatives considered include:

- Alternative 1 – No Further Action

- Alternative 2 – Institutional Controls (ICs) and Monitored Natural Recovery (MNR)
- Alternative 3 – Permanent Cap, ICs, and MNR
- Alternative 4 – Partial Solidification/Stabilization (S/S), Permanent Cap, ICs, and MNR
- Alternative 5 – Partial Removal, Permanent Cap, ICs, and MNR
- Alternative 6 – Full Removal of Materials Exceeding the Protective Concentration Level, ICs, and MNR

Each of these alternatives meets the CERCLA threshold criteria that a remedy: 1) provides for overall protection of human health and the environment; and 2) comply with the Applicable or Relevant and Appropriate Requirements (ARARs) identified for the Site.

To evaluate and compare these alternatives, chemical fate and transport modeling and hydrodynamic modeling were performed as documented in Appendix A and Appendix B, respectively, to this FS Report. The chemical fate and transport modeling was employed to assess the long-term effectiveness of each alternative. Short-term effectiveness was evaluated considering environmental impacts (to soil/sediment, water and tissue) during construction (based in part on chemical fate modeling), worker health and safety, and sustainability (qualitatively considered relative to greenhouse gas and particulate matter [PM] emissions and ozone impacts from construction equipment). Detailed costs were prepared for each alternative, as presented in Appendix C.

On a comparative basis, Alternatives 1, 2, and 3 provide greater long-term effectiveness than Alternatives 4, 5, and 6 because they avoid potentially significant environmental impacts related to releases during construction for the latter alternatives. Implementation of the TCRA effectively contained the waste deposits and impacted sediment in the TCRA Site. Implementation of Alternatives 1 and 2 would maintain the TCRA cap, and Alternative 3 would increase the long-term stability and provide for maintenance of the cap without disturbing the material that is already contained and isolated from potential receptors. Engineering analysis of the stability of a permanent cap (Alternative 3) has determined that the cap would remain protective when subjected to the erosive forces under any of the flow scenarios evaluated in the hydrodynamic modeling (Appendix B). In contrast, implementation of Alternatives 4, 5, or 6 would require removing all or part of the TCRA cap and moving waste deposits in the water column, resulting in suspension of waste and impacted sediment in the river. There is no increased long-term benefit from implementing Alternatives 4, 5, or 6; releases expected from these alternatives are found to result in a long-term detriment when compared to Alternatives 1, 2, and 3.

For short-term effectiveness, Alternatives 1 and 2 are most favorable, followed by Alternative 3. Alternatives 4, 5, and 6 are significantly less favorable due to environmental impacts and worker safety concerns. Risks of implementation of Alternatives 4, 5, and 6 include the potential for unavoidable release of dioxins/furans into the water column outside of the work area (both from impacted sediments, as well as dissolved phase), an outcome that has been documented at other sediment remediation projects in spite of significant efforts made to prevent or control such releases. Worker safety risks, greenhouse gas, and PM emissions and ozone impacts are estimated to be more than 8 to 20 times higher for Alternatives 4, 5, and 6 compared to Alternative 3. Traffic and community impacts for Alternatives 4, 5, and 6 (measured as truck trips) are estimated to range from 6 to 70 times greater than Alternative 3.

Costs for the response action alternatives range from $1.3 million to over $600 million. Costs for Alternatives 4, 5, and 6 are significantly higher than for Alternatives 1, 2, and 3, reflecting the difficulty of implementing these alternatives, as well as the high cost of disposal of dioxin-impacted sediments.

Based on the considerations presented in this FS Report, Alternative 3 is the preferred alternative for the SJRWP Site. Alternatives 4, 5, and 6 each offer less environmental benefit or reduction in risks, greater uncertainties related to implementation, an extended construction schedule, higher short-term environmental impacts, increased safety risks, higher community impacts, and significantly greater cost.

1 INTRODUCTION

This Feasibility Study (FS) Report was prepared for the San Jacinto River Waste Pits (SJRWP) Superfund Site (Site) (Figure 1-1, showing the time critical removal action [TCRA] Site and vicinity) on behalf of IP and MIMC (collectively referred to as the Respondents for the Site). The location of U.S. Environmental Protection Agency [USEPA's] Preliminary Site Perimeter is shown on Figure 1-2. This FS Report builds upon the final Remedial Alternatives Memorandum (RAM), which presented the screening of remedial technologies and the development of preliminary remedial alternatives. The Draft RAM was conditionally approved by USEPA on November 14, 2012 (USEPA 2012b) and the revised, final version was submitted to USEPA on December 3, 2012 (Anchor QEA 2012b). This FS Report develops and evaluates remedial alternatives for the SJRWP Site based on the Remedial Action Objectives (RAOs) provided in the RAM and Remedial Investigation (RI) Report (Integral and Anchor QEA 2013a), and based on results of the Baseline Human Health Risk Assessment (BHHRA) (Integral 2013b) and Baseline Ecological Risk Assessment (BERA) (Integral 2013a). The BERA and BHHRA were conditionally approved by USEPA on February 26, 2013 and May 22, 2013, respectively. The Final BERA and BHHRA were submitted to USEPA on May 6, 2013 and May 22, 2013, respectively.

1.1 Purpose and Organization of the Report

The FS Report evaluates remedial alternatives for the Site, and is consistent with specific guidance (USEPA 1988) as required by the Unilateral Administrative Order (UAO; USEPA 2009a). The identification and screening of remedial technologies, which the guidance includes as an element of the FS Report (Table 6-5, USEPA 1988), is discussed in the RAM (Anchor QEA 2012b), as was required by the UAO.

The remainder of Section 1 provides a summary of the regulatory background with respect to the Site. Section 2 provides a summary of Site information as presented in previous documents prepared and submitted in support of the RI/FS process, including a summary of the Site setting and history, the nature and extent of contamination, chemical fate and transport, results of the BERA and BHHRA, and the Conceptual Site Models (CSM) for the SJRWP Site. The other sections of the FS Report address the following:

- Section 3 identifies the protective concentration levels (PCLs) described in the RI

Report and identified by USEPA and describes the basis for the remedial action

- Section 4 describes the development of each remedial alternative
- Section 5 provides a detailed and comparative analysis of each remedial alternative
- Section 6 provides the comparative analysis of the remedial alternatives, and describes the recommended remedy
- Section 7 provides the references

1.2 Regulatory Background

On March 19, 2008, the USEPA listed the SJRWP Site on the National Priorities List (NPL) under Comprehensive Environmental Response Compensation and Liability Act (CERCLA), also known as Superfund, due to presence of metals and dioxins and furans (Texas Commission on Environmental Quality [TCEQ] and USEPA 2006, 2008) in soils and sediments at the SJRWP Site. On November 20, 2009, USEPA issued a UAO to IP and MIMC (USEPA 2009a). The 2009 UAO directs IP and MIMC to conduct an RI/FS for the SJRWP Site.

This document satisfies the requirement of the Statement of Work in the UAO for the submittal of a FS Report following receipt of USEPA approval of the Final RI Report (Integral and Anchor QEA 2013a). The RI Report was conditionally approved by USEPA on April 4, 2013, and the Final RI Report was submitted to USEPA on May 17, 2013. The FS Report will ultimately lead to a proposed remedial action plan for the SJRWP Site. The remedial action plan will be incorporated into a USEPA Record of Decision (ROD) that outlines cleanup actions to address potential threats to human health and the environment at the SJRWP Site.

The UAO describes a basic history of the SJRWP Site, but it addresses only the impoundments located on the north side of Interstate Highway 10 (I-10), referred to as the Northern Impoundments. USEPA subsequently required investigation of soil and groundwater in an area to the south of I-10, or “Soil Investigation Area 4” citing historical documents indicating possible waste disposal activities in that area (Figure 1-2). The area of investigation south of I-10 ultimately also included areas adjacent to Soil Investigation Area 4, at locations to the south and west of it, where USEPA required additional soil and groundwater samples.

A TCRA was completed in July 2011 in the Northern Impoundments, pursuant to an Administrative Settlement Agreement and Order on Consent for Removal Action: CERCLA Docket No. 06-12-10 (AOC) (USEPA 2010a). The TCRA stabilized pulp waste and sediments within the original 1966 perimeter berm of the Northern Impoundments to prevent any releases of dioxins and furans and other chemicals of potential concern (COPCs) to the environment (Anchor QEA 2011a, 2012a). More information about the TCRA is provided in Section 2.5.3.

2 SETTING

This section provides a summary of information gathered concerning physical, chemical, and biological conditions within the USEPA's Preliminary Site Perimeter. This information is intended to provide the reader with an understanding of the SJRWP Site and the human actions, natural processes, and physical properties that may influence the nature and extent of chemicals of concern (COCs) within the USEPA's Preliminary Site Perimeter, and that may influence evaluation of remedial alternatives presented in Sections 4 through 6 of this report. A more comprehensive physical and biological description, as well as more detailed history of the area within the USEPA's Preliminary Site Perimeter, its environmental setting, and land uses are provided in the RI Report (Integral and Anchor QEA 2013a).

2.1 Location and History

USEPA's Preliminary Site Perimeter includes several waste impoundments within the estuarine section of the San Jacinto River, as well as surrounding in-water and upland areas. The impoundments are located on the western side of the San Jacinto River, north and south of I-10 (Figure 1-1). The area within the USEPA's Preliminary Site Perimeter is generally flat with very little noticeable topographic relief across most of the area.

The impoundments adjacent to the river on both the north and south sides of I-10 were built in the mid-1960s for disposal of paper mill wastes, reportedly barged from the Champion Paper Inc. paper mill in Pasadena, Texas. These wastes are considered to be a source of dioxins and furans present within the USEPA's Preliminary Site Perimeter and have been targeted for remediation. Other sources of dioxins and furans within USEPA's Preliminary Site Perimeter, such as atmospheric inputs, industrial effluents, publicly owned treatment works, and storm water runoff, are discussed in Section 2.6.4. Over time, a variety of actions occurring within and in the vicinity of the USEPA's Preliminary Site Perimeter resulted in actual or potential disturbances to the impoundments, and introduced other sources of dioxins and furans, as well as other COCs into the soils and sediments within the USEPA's Preliminary Site Perimeter.

Large scale groundwater extraction, resulting in regional subsidence of land in the vicinity of the SJRWP Site, as well as dredging and sand mining within the river and marsh to the west and northwest of the Northern Impoundments through the 1990s and early 2000s, resulted in exposure of the contents of the Northern Impoundments to surface waters. Historical documents indicate that dredging actions also occurred in the river in the vicinity of the upland sand separation area. In addition, barge maintenance and cleaning activities conducted on and adjacent to the upland sand separation area (west of the Northern Impoundments) in the mid-1990s by Southwest Shipyards included generation and storage of unspecified hazardous materials and wastes, including residual spent blast sand, paint chips, and rust chips swept from vessels prior to painting, paint drip, and overspray (GW Services 1997).

The peninsula south of I-10 and the area of investigation south of I-10 were characterized by intense industrial activity in the 1980s based on review of historical aerial images (Integral and Anchor QEA 2013a). Southwest Shipyards' activities also have impacted areas south of I-10, including the western shoreline of the peninsula south of I-10 (GW Services 1997). Most of the upland area south of I-10 is currently in industrial or commercial use by marine services companies, with some parcels currently unused.

A more detailed discussion of the SJRWP Site history is provided in Sections 5.1 and 6.1 of the RI Report (Integral and Anchor QEA 2013a).

2.2 Land Use

The land use types in the area surrounding the USEPA's Preliminary Site Perimeter are shown on Figure 2-1. The land parcels closest to the USEPA's Preliminary Site Perimeter are predominantly commercial/industrial, followed by residential areas. Moving farther from the USEPA's Preliminary Site Perimeter, the amount of residential land use increases. Upstream of the USEPA's Preliminary Site Perimeter, land uses include industrial and municipal activities that may result in releases of dioxins and furans or other COPCs into the San Jacinto River.

2.2.1 Recreational and Navigational Use

The RI Report presents information regarding recreational and navigational use of the river and the area within the USEPA's Preliminary Site Perimeter. An advisory (ADV-49[1]) regarding the consumption of fish and blue crab exists on the San Jacinto River, including the area within the USEPA's Preliminary Site Perimeter. Sections 3.3.1 and 3.7.3 of the RI Report (Integral and Anchor QEA 2013a) discuss surface water use and fishing advisories. Although fishing was reported to have occurred prior to TCRA implementation, there have been no systematic studies of the amount and frequency of fishing that may have occurred within the USEPA's Preliminary Site Perimeter prior to the implementation of the TCRA. The completion of the TCRA resulted in reduced public access to the Northern Impoundment area. Perimeter fencing was installed and warning buoys and signs were placed around the TCRA Site. In addition, access to the TCRA Site via boat is currently constrained to the north, west, south, and southeast by industrial use and navigational hazards (i.e., submerged sand bars and shallow water).

The commercial and industrial navigational use of the waterway is generally restricted by shallow depths outside the prescribed channel, as well as other "foul areas" where unidentified hazards are likely to exist. There is no Federally authorized navigation channel in the portions of the river within the USEPA's Preliminary Site Perimeter, and vessel heights are limited in the vicinity of the TCRA Site due to clearance limits under the I-10 Bridge. Barge fleeting and mooring occurs in many areas within the USEPA's Preliminary Site Perimeter, including the San Jacinto River Fleet (SJRF) operations near the former upland sand separation area west and northwest of the TCRA Site (Figure 1-2).

2.3 Biological Habitat

The USEPA's Preliminary Site Perimeter is located within a low gradient, tidal estuary near the confluence of the San Jacinto River and the Houston Ship Channel (HSC). The surrounding area includes Lynchburg Reservoir to the southeast and the Lost Lake sediment management area (SMA) west of Lynchburg Reservoir (Figure 2-2). The I-10 freeway

[1] http://www.dshs.state.tx.us/seafood/survey.shtm and http://www.tpwd.state.tx.us/regulations/outdoor-annual/fishing/general-rules-regulations/fish-consumption-bans-and-advisories.

reduces the connectivity of habitats in the natural areas to the north and south of the highway, and industrial land use has diminished the habitat value of the uplands and aquatic areas within the USEPA's Preliminary Site Perimeter.

Some upland natural habitat adjacent to the river within the USEPA's Preliminary Site Perimeter remains, consisting primarily of clay and sand that support a variety of forest community types including composites such as loblolly pine-sweetgum, loblolly pine-shortleaf pine, water oak-elm, pecan-elm, and willow oak-blackgum (TSHA 2009). It is reasonable to expect a suite of generalist terrestrial species that are not highly specialized in their habitat requirements and are adapted to moderate levels of disturbance (Integral 2013). Such species could include reptiles and amphibians (e.g., snakes, turtles), birds (e.g., starlings, pigeons), and mammals common to semi-urban environments (e.g., rodents, raccoons, and coyotes).

Wildlife habitats within the northern portion of USEPA's Preliminary Site Perimeter include shallow and deep estuarine waters, and shoreline areas occupied by estuarine vegetation. A sandy intertidal zone is present along the shoreline throughout much of the USEPA's Preliminary Site Perimeter (Figure 2-2). The tidal portions of the river and upper Galveston Bay provide rearing, spawning, and adult habitat for a variety of marine and estuarine fish and invertebrate species. Species known to occur in the vicinity of the USEPA's Preliminary Site Perimeter include: clams and oysters, blue crab (*Callinectes sapidus*), black drum (*Pagonius cromis*), southern flounder (*Paralichthys lethostigma*), hardhead (*Ariopsis afelis*) and blue catfish (*Ictalurus furcatus*), spotted sea trout (*Cynoscion nebulosis*), and grass shrimp (*Paleomonetes pugio*) (Gardiner et al. 2008; Usenko et al. 2009). An estimated 34-acres of estuarine and marine wetlands are found within the USEPA's Preliminary Site Perimeter (Integral and Anchor QEA 2013a).

On the peninsula to the south of I-10, most of the upland is zoned for commercial or industrial use. Minimal habitat is present in the upland terrestrial area within the USEPA's Preliminary Site Perimeter. Demolition of former industrial facilities and current operations in support of barge fleeting and other industrial activities have created a denuded upland with a covering of crushed concrete and sand. The sandy shoreline of this area has scattered riprap, other metal debris, and piles of concrete fragments. The upland vegetation present on the peninsula south of I-10 is primarily low-lying grasses, with a few shrubs and trees adjacent to the shoreline.

A more detailed description of the local ecological system can be found in Section 3.8 of the RI Report (Integral and Anchor QEA 2013a) and in Section 3.4 of the BERA (Integral 2013a).

2.4 Physical Description

2.4.1 Waterway Hydrodynamics

Water depths within the USEPA's Preliminary Site Perimeter range from relatively shallow in intertidal areas (3 feet or less) to relatively deep in the main channel of the river (about 30 feet). The typical tidal range in the river is about 1 to 2 feet, with neap and spring tide conditions corresponding to minimum and maximum tidal ranges, respectively. Tropical storms and wind storms from the north can have significant effects on water levels within the USEPA's Preliminary Site Perimeter. Tropical storms can cause storm surges with water levels that are 4 to 6 feet higher than typical tidal elevations, and storms with strong winds from the north can cause water to be transported out of the Galveston Bay system, which can result in water levels that are much lower than low tide elevations.

The San Jacinto River within the USEPA's Preliminary Site Perimeter is a well-mixed estuarine system. Flow rates and freshwater inputs in the river in the vicinity of the USEPA's Preliminary Site Perimeter are partially controlled by the Lake Houston dam, upstream of the USEPA's Preliminary Site Perimeter. Salinity ranges from 2 to 20 parts per thousand, but may approach 0 parts per thousand during flood conditions (Integral and Anchor QEA 2013a). The average flow rate in the river is 2,200 to 2,600 cubic feet per second (cfs), based on a flood frequency analysis presented in the RI Report (Integral and Anchor QEA 2013a). Floods in the river primarily occur during tropical storms (e.g., hurricanes) or intense thunderstorms. Flood events with return intervals of 25 years or more have flow rates of 200,000 cfs or greater (Integral and Anchor QEA 2013a). In October 1994, an approximate 100-year flood event had a peak discharge of 360,000 cfs, and a maximum river stage height of 27 feet above mean sea level (MSL) (Integral and Anchor QEA 2013a).

During low-flow conditions when current velocities were dominated by tidal effects, maximum velocities were measured to be about 1 foot per second, with typical velocities of 0.5 feet per second or less during most of the tidal cycle (Integral and Anchor QEA 2013a).

2.4.2 Riverbed Characteristics and Sediment Transport

A detailed evaluation and analysis of the riverbed and sediment transport processes within the USEPA's Preliminary Site Perimeter was presented in the RI Report, as well as in the Chemical Fate and Transport Modeling Report (Anchor QEA 2012c).

The nature of the sediment bed affects sediment transport processes, as well as chemical distributions. As described in the RI Report, the sediment bed within the USEPA's Preliminary Site Perimeter is composed of approximately 80 percent cohesive (i.e., muddy) and 20 percent non-cohesive (i.e., sandy) sediments (Integral and Anchor QEA 2013a). Erosion rate data of cohesive sediment collected in the San Jacinto River indicate that the erodibility of bed sediment decreases with increasing depth in bed (Anchor QEA 2012c). The primary source of sediment to the San Jacinto River and within the USEPA's Preliminary Site Perimeter is suspended sediment in surface waters discharged from the Lake Houston Dam. The average annual sediment load at the dam is approximately 381,000 metric tons (Anchor QEA 2012c).

Sediment stability within the USEPA's Preliminary Site Perimeter may be affected by human activities and natural processes as discussed in the RI Report (Integral and Anchor QEA 2013a):

- Near-bed velocities generated by episodes of propeller wash are expected to be significantly higher than those due to tidal and riverine currents in areas of the river that are subjected to vessel operations (e.g., at the SJRF operations). Bed-shear stress due to vessel operations is expected to be higher than bed-shear stress due to natural forces and may have the potential to disturb sediments in these vessel operation areas.
- Although the rate of subsidence has significantly decreased during the last 35 to 40 years, due to controls on groundwater usage within Harris County, the effect of subsidence in the future, if it occurs on bed sediments in the San Jacinto River, will be to reduce the potential for erosion. Subsidence lowers the sediment bed elevation,

and thus, increases water depth and decreases current velocities, which in turn reduces potential for bed erosion.

- Sea level rise is projected to continue at a rate of approximately 2 to 3 millimeters per year (mm/year) during the next century, with a total increase in sea level of about 0.5 to 2 feet by the year 2100 (Anchor QEA 2012c). The effect of sea level rise on bed sediment in the San Jacinto River will be to reduce the potential for erosion because rising sea level increases water depths, which generally decreases current velocities.

The stability of the sediment bed is an important factor for considering natural recovery processes and in evaluating remedial alternatives for deeply buried deposits of sediment that might exceed the identified PCLs (discussed in Section 3.1) for the areas within the USEPA's Preliminary Site Perimeter. Evaluation of the radioisotope coring data from within the USEPA's Preliminary Site Perimeter indicates the net sedimentation rate (NSR) is approximately 0.4 to 3.9 centimeters per year (cm/year) in depositional areas (Anchor QEA 2012c). The effects of changes in sediment load from upstream sources on long-term sedimentation were evaluated during the modeling study and are discussed in the Chemical Fate and Transport Modeling Report (Anchor QEA 2012c), as well as in Appendix A of this report. Sedimentation rates may change with time if land use restrictions, discharge limitations, or other regulatory developments related to storm water discharge are implemented within the San Jacinto River basin; however, sediment loads from sources located downstream of Lake Houston dam are minimal compared to the load at the dam (Anchor QEA 2012c). Thus, any potential decreases in loads downstream of the dam in the future will have negligible effect on long-term sedimentation within the USEPA's Preliminary Site Perimeter.

2.5 Nature and Extent of COCs

The RI Report (Integral and Anchor QEA 2013a) contains an in-depth discussion of the process involved to identify COCs within the USEPA's Preliminary Site Perimeter, and the nature and extent of COCs north of I-10 (RI Report Section 5.2) and the area of investigation south of I-10 (RI Report Section 6.2). Based on sediment data and the results of the BERA and BHHRA, dioxins and furans were identified as the indicator chemical group for the purposes of the RI/FS (see Appendix C of the RI/FS Work Plan; COPC Technical

Memorandum [Integral 2011], and the RAM [Anchor QEA 2012b]). This section discusses the nature and extent of COCs focusing specifically on this chemical group.

2.5.1 North of I-10

Under baseline conditions, the highest 2,3,7,8-tetrachlorinated dibenzo-*p*-dioxin toxic equivalents (TEQ) concentrations calculated for mammalian receptors using dioxins and furans only ($TEQ_{DF,M}$) in sediment were found in the area of the Northern Impoundments, which corresponds to the area capped by the TCRA. Outside of the TCRA Site, $TEQ_{DF,M}$ concentrations in sediment and soils are significantly lower. Figure 2-3 presents the $TEQ_{DF,M}$ concentrations in surface sediment. As presented, concentrations for each sample are color-coded based on powers of 10 to facilitate identifying areas of similar concentration. Figure 2-4 presents $TEQ_{DF,M}$ concentrations in samples collected from sediment cores. The $TEQ_{DF,M}$ concentrations in sediment are discussed in the context of the PCLs in Section 3.1.

The RI Report also examined concentrations of polychlorinated biphenyls (PCBs) and mercury in the TCRA Site soils/sediments. The source evaluation of the area north of I-10 and surrounding aquatic environments presented in Section 5.4 of the RI Report concluded that the PCB concentrations in sediments within the USEPA's Preliminary Site Perimeter, but outside the Northern Impoundments are not highly elevated relative to areas outside of the USEPA's Preliminary Site Perimeter and contribute very little dioxin-like toxicity to the sediment. In addition, because mercury concentrations in the soils on the upland sand separation area located on the SJRF property (as shown on Figure 1-2), are higher than they are in the wastes within the Northern Impoundments, the wastes within the Northern Impoundments are not the primary source of mercury in the aquatic environment under investigation.

2.5.2 Area of Investigation South of I-10

Available historical documentation indicates that some of the wastes deposited within Soil Investigation Area 4 may have originated from the Champion Paper Inc. paper mill (TDH 1966). As noted in the RI Report, the BHHRA for the area of investigation on the peninsula south of I-10 found no health risks in surface soil to hypothetical trespassers and hypothetical commercial workers above the thresholds considered acceptable by USEPA.

For hypothetical future construction workers, exposure scenarios for three individual core locations (each assumed to be representative of a potential building site, and assuming excavation or other activities that would disturb the soil) resulted in noncancer and dioxin cancer hazard indices greater than 1. Dioxins and furans, as $TEQ_{DF,M}$ were identified as COCs for the hypothetical future construction worker, based on hypothetical future exposures to the upper 10 feet of soil. A full description of the risk evaluation assumptions, uncertainties, and data evaluation is provided in the BHHRA (Integral 2013b).

The BERA for the area of investigation south of I-10 identified low risks to terrestrial bird populations from lead and zinc. Lead and zinc were therefore identified as COCs. Soil PCLs were not developed for these metals because of uncertainties associated with the exposure modeling that likely overestimated exposures, and because these two metals are not associated with paper mill waste, but are likely present due to other industrial activities within the area of investigation on the peninsula south of I-10.

Figure 2-5 presents $TEQ_{DF,M}$ concentrations in surface and subsurface soil in the area south of I-10. The data are discussed relative to the PCL for a hypothetical future construction worker and a hypothetical future commercial worker in Section 3.1. The exposure scenario for the hypothetical future construction worker receptor assumes exposure to a depth-weighted average of TEQ concentrations throughout a 10 foot soil depth, but the most elevated $TEQ_{DF,M}$ concentrations are found in samples from several feet below grade. As discussed in the BHHRA and the RI Report, several feet of relatively clean soil isolates the soil with the highest $TEQ_{DF,M}$ concentrations from potential receptors at the surface.

2.5.3 Prior Actions at the SJRWP Site

As discussed in Section 1.2, a TCRA was implemented, pursuant to an AOC, to stabilize pulp waste and sediments within the original 1966 perimeter berm of the Northern Impoundments (Anchor QEA 2011a; Anchor QEA 2011b). As presented in the Action Memorandum (USEPA 2010a, Appendix A) for the TCRA, the following removal action objectives for the TCRA were identified:

- Stabilize waste pits to withstand forces sustained by the river.

- The barrier design and construction must be structurally sufficient to withstand forces sustained by the river including any future erosion and be structurally sound for a number of years until a final remedy is designed and implemented (USEPA 2010a).
- Technologies used to withstand forces sustained by the river must be structurally sufficient to withstand a storm event with a return period of 100-years until the nature and extent of contamination for the Site is determined and a final remedy is implemented.

- Prevent direct human contact with the waste materials (USEPA 2010a, Appendix A, IV.A.1; Page 9; first paragraph).
- Prevent benthic contact with the waste materials (USEPA 2010a, Appendix A, III.B).
- Ensure that the "actions are consistent with any long term remediation strategies that may be developed for the Site" (USEPA 2010a, Appendix A, V.A.2).

During the design of the TCRA, the area within the original 1966 perimeter of the Northern Impoundments was divided into three distinct areas: 1) the Eastern Cell; 2) the Western Cell; and 3) the Northwestern Area (Figure 2-6). In general, the TCRA design included an armor rock cap placed atop a geotextile bedding layer in all but the Northwestern Area. Additionally, the Western Cell received treatment through stabilization/solidification (S/S) of approximately 6,000 cubic yards (cy) of material in the upper 3 feet of soil over a 1.2 acre portion of the area, and a geomembrane cover layer prior to armor rock installation. The TCRA cap is discussed further in Section 4 relative to the remedial alternatives, and shown on the figures from that Section. In addition to capping the Northern Impoundments, the TCRA upland perimeter was fenced and signage was installed to prevent unauthorized access to the TCRA Site. A description of the TCRA implementation is provided in the Removal Action Completion Report (RACR) (USEPA 2012c).

2.5.3.1 Effect of Time Critical Removal Action

The post-TCRA evaluation indicates that the TCRA's implementation has effectively reduced potential risks from dioxins and furans associated with baseline conditions. The following sections discuss effects of TCRA implementation on sediment, water, and tissue.

2.5.3.1.1 Sediment

Implementation of the TCRA has eliminated the potential transport of waste associated COCs from the Northern Impoundments. The effect of the TCRA on overall sediment quality within the USEPA's Preliminary Site Perimeter was evaluated in the RAM by performing a "hilltopping" evaluation comparing the surface weighted average concentration (SWAC) of $TEQ_{DF,M}$ within the USEPA's Preliminary Site Perimeter for various prospective remedial action levels (RALs), including SWACs before TCRA implementation and following TCRA completion. As documented in the RAM, the $TEQ_{DF,M}$ SWAC was reduced by more than 80 percent by implementing the TCRA. In addition, on-going natural recovery continues to reduce surface sediment concentrations outside of the TCRA Site, as indicated by the long-term chemical fate model simulations presented in Appendix A.

2.5.3.1.2 Water

As shown in the TCRA cap porewater assessment in Section 5.3 of the RI Report, sampling conducted after construction of the TCRA cap was completed of surface water and porewater with solid phase microextraction (SPME) fibers indicated that 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and 2,3,7,8-tetrachlorodibenzofuran (TCDF) were not present in surface water over the armor cap. Data generated from this porewater assessment support evaluation of remedial alternatives that incorporate the TCRA cap into the final remedy.

The chemical fate and transport modeling presented in Appendix A was used to evaluate the potential for reductions in surface water concentrations associated with implementation of the TCRA. The model results showed that as a result of the TCRA cap, annual average concentration estimates of 2,3,7,8-TCDD predicted by the model in surface water have decreased by approximately 85 percent in the area of the TCRA Site and by 40 percent when averaged over the USEPA's Preliminary Site Perimeter. As discussed in Appendix A, the concentrations predicted by the model for post-TCRA conditions reflect dioxin/furan inputs associated with a number of sources, including transport from upstream, atmospheric deposition, surface runoff, point discharges (industrial and municipal treatment plant effluents), and fluxes from surface sediment outside the footprint of the TCRA Site.

2.5.3.1.3 Tissue

Completion of the TCRA construction in July 2011 rendered sediments in the TCRA Site inaccessible for direct contact by humans, benthos, fish, and aquatic dependent wildlife, and are therefore expected to lead to reductions in tissue concentrations in catfish and clams within the USEPA's Preliminary Site Perimeter.

2.5.4 Sources of COCs

The chemical fate and transport modeling, discussed in Section 2.6.7 and Appendix A, concluded that ongoing deposition of sediment within the USEPA's Preliminary Site Perimeter will continue to reduce concentrations of dioxins and furans in sediment. As noted in the RI Report, a number of historical and current sources of dioxins, furans, and other COCs remain as ongoing contributors to COC concentrations found within the USEPA's Preliminary Site Perimeter.

The chemical analyses of groundwater, soils, and sediments presented in both the Preliminary Site Characterization Report (PSCR; Integral and Anchor QEA 2012) and the RI Report demonstrated that other regional sources – such as atmospheric inputs, industrial effluents, publicly owned treatment works, and storm water runoff – contribute dioxins and furans and other COCs (metals, and PCBs) found in the TCRA Site area and surrounding aquatic environment. In the area of investigation south of I-10, historical and ongoing industrial marine services are known to contribute chemicals, including COCs for ecological receptors, to soils.

The "unmixing" evaluations based on fingerprinting evaluations of dioxin and furan mixtures in soil and sediment samples described in the RI Report demonstrate that not all of the dioxins and furans in sediment and soils within the Northern Impoundment and Soil Investigation Area 4 are from paper mill wastes. Sediments within the USEPA's Preliminary Site Perimeter contain a specific distribution of individual dioxin and furan congeners that is likely attributable to the urban background and specific regional sources surrounding the USEPA's Preliminary Site Perimeter, as well as at least one point source within the USEPA's Preliminary Site Perimeter.

In the peninsula south of I-10, soils and subsurface soils contain dioxins and furans from a mixture of sources including paper mill wastes, as well as other background or site-specific sources. The unmixing analysis for soils collected from the area of investigation south of I-10 indicates that there are three distinctive dioxin and furan source types contributing to the presence of dioxins and furans in soils sampled south of I-10 including one that resembles paper mill wastes, one that resembles background dioxin and furan sources, and a third mixture unique to this area. The dioxin and furan mixture towards the southern end of Soil Investigation Area 4 in shallower soils is consistent with the fingerprint characteristic of paper mill wastes, based on fingerprints of samples collected from within the impoundments north of I-10. In deeper soils at the southern and northern ends of the area of investigation on the peninsula south of I-10, the dioxin and furan mixture describes a different source type that is not observed elsewhere within the USEPA's Preliminary Site Perimeter, and does not appear to match apparent source types in other soils or sediment samples collected from within the USEPA's Preliminary Site Perimeter nor any known anthropogenic source pattern in the USEPA Dioxin Reassessment database (USEPA 2004). The general spatial distribution of sources that differ from the paper mill wastes in soils suggests that dioxin and furan containing material was deposited into, or on the peninsula south of I-10, at a point in time prior to disposal of paper mill wastes. Finally, outside of Soil Investigation Area 4, the dioxin and furan mixtures are generally dominated by a fingerprint consistent with general urban background sources. The unmixing analysis demonstrates that paper mill wastes are mostly confined to the area within USEPA's estimated perimeter of the impoundment. Spatial patterns of dioxins and furans and other chemicals within subsurface soils in the area of investigation south of I-10, as well as waste materials (such as paint chips, construction debris, plastics, and asphalt shingles) and chemicals not associated with paper mill wastes, also support the conclusion that wastes other than paper mill wastes have contributed to the presence of dioxins and furans in soils in the area of investigation south of I-10 (see RI Report Section 6.6).

2.5.5 Chemical Fate and Transport

Section 5.6 of the RI Report contains a summary of the chemical fate and transport processes affecting the concentrations of dioxins and furans within the USEPA's Preliminary Site Perimeter. The most significant points of this discussion are summarized below:

- Sediment-water interactions – Dioxins and furans are hydrophobic and preferentially bind to particulate matter (PM). Particulate-associated dioxins and furans within the sediment bed enter the water column through sediment deposition and erosion processes described in Section 2.5. Deposition of sediments with low concentrations of chemicals may support natural recovery.
- Partitioning and dissolved phase flux – Because dioxins and furans are hydrophobic, they will be present primarily in particulate form, and their fate is therefore determined largely by sediment transport processes. Dioxins and furans within the sediment matrix include dissolved-phase dioxins and furans in porewater through partitioning processes, which can result in a transfer of dissolved-phase mass to the water column under certain conditions.
- Transport in the water column – Dioxins and furans present in the water column in any phase are transported by surface water currents, which are affected by hydrodynamic processes within the larger San Jacinto River.
- External sources – Publicly owned treatment plant outfalls, other point-source discharges, storm water runoff and atmospheric deposition are all sources of dioxins and furans within USEPA's Preliminary Site Perimeter. As documented in the RI Report, groundwater is not a significant source of dioxins or furans to the San Jacinto River. The modeling described in Appendix A includes contributions from these external sources.

A detailed description of the modeling is provided in the Chemical Fate and Transport Modeling Report (Anchor QEA 2012c), and supporting documentation. More detailed discussions of dioxin and furan bioaccumulation in aquatic biota are presented in the Technical Memorandum on Bioaccumulation Modeling (Integral 2010), Section 5.6 of the RI Report (Integral and Anchor QEA 2013), and in the BERA (Integral 2013).

2.5.5.1 Bioaccumulation

The data analyses and literature review presented in the Technical Memorandum on Bioaccumulation Modeling (Integral 2010), including evaluation of region-specific multivariate datasets, indicates that the majority of dioxin and furan congeners do not consistently bioaccumulate in fish or invertebrate tissue. This is due to biological controls on uptake and excretion in both fish and invertebrates (Integral 2010). As a result, systematic predictions of bioaccumulation from concentrations of dioxins and furans in abiotic media (both sediment and water) are only possible for tetrachlorinated congeners. However, even these correlations are weak, and are associated with high uncertainty (Integral 2010a).

Analyses presented in the BERA (Integral 2013a) indicated that concentrations of 2,3,7,8-TCDD and 2,3,7,8-TCDF in the tissues of clams and killifish (which have limited spatial movements) were higher in those clams and killifish taken in proximity to the Northern Impoundments (prior to TCRA construction). Consistent with the literature (USEPA 2009b), benthic species (clams and catfish) had higher concentrations of dioxins and furans than predatory fish species, suggesting that concentrations of dioxins and furans are not predicted by position in the food chain, but are accumulated more as a function of proximity to sediment in which dioxins and furans are present. Combined with the fact that concentrations in clam tissue correlate reasonably well with concentrations in sediments adjacent to where they were collected reinforces the "proximity hypothesis" in support of the conceptual framework for bioaccumulation of dioxin and furans, outlined in the Technical Memorandum on Bioaccumulation Modeling (Integral 2010).

2.5.6 Fate and Transport Modeling

A comprehensive fate and transport model was developed to support the RI/FS. The fate and transport model development and calibration is provided in the Chemical Fate and Transport Modeling Study Report (Anchor QEA 2012c). The primary goal of the modeling study was to simulate physical and chemical processes that are controlling chemical fate and transport of selected dioxins and furans within the aquatic environment of the area within the USEPA's Preliminary Site Perimeter. Specifically, the primary objectives of the chemical fate and transport analysis were threefold:

- Develop a CSM for sediment transport and chemical fate and transport.
- Develop and apply quantitative methods (i.e., computer models) that can be used to evaluate the effectiveness of various remedial alternatives during the FS.
- Address specific questions about sediment transport and chemical fate and transport processes within the USEPA's Preliminary Site Perimeter.

The mathematical modeling framework that was applied consists of three models that were linked together: hydrodynamic, sediment transport, and chemical fate and transport. These models were developed, calibrated, and tested (as described in Anchor QEA 2012c) and together form a quantitative framework that can be used as a management tool that can help guide remedial decision making. The calibration and validation of the model framework indicates that that it can simulate hydrodynamics, sediment transport, and chemical fate and transport within the Model Study Area (i.e., San Jacinto River from Lake Houston Dam to the confluence with the HSC) with sufficient accuracy to support its use to make relative comparisons among remedial alternatives in the FS Report. The above notwithstanding, the models do have uncertainty due to data limitations, particularly for dioxins and furans in surface water.

Overall, the modeling framework provides a useful management tool to develop future predictions of dioxin and furan concentrations in sediment and surface water within the USEPA's Preliminary Site Perimeter. Specific FS model applications, which are presented in Appendix A, included the following:

- Long-term simulations of post-TCRA future conditions (i.e., starting from current conditions, which include the presence of the TCRA cap over the TCRA Site) were conducted. These simulations provide estimates of rates of natural recovery (i.e., reductions in estimated water column and surface sediment dioxin and furan concentrations over time) in various portions of the Model Study Area, which are representative of conditions anticipated for Alternatives 1 through 3 described in Section 4 below.
- In addition, long-term simulations of alternatives containing in-water sediment remediation (i.e., Alternatives 4 through 6 described in Section 4 below) were also conducted. Future sediment and water column dioxin and furan concentrations from these simulations were used to evaluate potential short- and long-term impacts associated with the construction activities (i.e., sediment resuspension and release during sediment remediation and effects of dredge residuals).

Results from the fate and transport modeling conducted to support the alternatives analysis are described in detail in Appendix A to this FS Report. Appendix A also includes a description of model uncertainty analyses that were conducted to develop uncertainty bounds around its predictions, as well as a summary of certain sensitivity analyses that were performed with the hydrodynamic and sediment transport models at the request of USEPA in its letter approving the draft final report for the modeling study.

3 BASIS FOR REMEDIAL ACTION

The basis for undertaking remedial action is to address the potential risks associated with the presence of dioxin and furan containing sediment resulting from historical paper mill waste disposal in the Northern Impoundments, as well paper mill wastes present in the Soil Investigation Area 4, south of I-10. This section discusses the development of PCLs, reviews the RAOs established by USEPA for the area within the USEPA's Preliminary Site Perimeter, and reviews the Applicable or Relevant and Appropriate Requirements (ARARs) that have been identified in previous documents.

3.1 Recommended Protective Concentration Levels

The RAOs are focused on remedial measures applicable to sediments and soils within the USEPA's Preliminary Site Perimeter to reduce potential exposure pathways to humans and ecological receptors. Therefore, the PCLs utilized in the development of remedial alternatives are those developed for soils and sediments. All of the PCLs used in the evaluation of alternatives were approved by USEPA, and are based on $TEQ_{DF,M}$ concentrations that are protective of human health, based on the Reasonable Maximum Exposure (RME) scenario for the subject hypothetical receptors.

PCLs were developed as described in the RI Report and the May 14, 2013 letter from Anchor QEA to USEPA Region 6 (Anchor QEA 2013). The PCLs for the hypothetical recreational visitor and hypothetical future construction worker were presented in the RI Report, which was approved by USEPA; the PCL for the hypothetical future outdoor commercial worker was developed in cooperation with the USEPA during preparation of the FS using methodologies contained in USEPA guidance documents and presented in the May 14, 2013 letter. The development of PCLs considered all potential exposure pathways associated with hypothetical receptor exposure scenarios approved by USEPA, including reasonably anticipated future uses of specific areas within the USEPA's Preliminary Site Perimeter, and all COCs for each medium. Based on consideration of reasonable potential future uses within the USEPA's Preliminary Site Perimeter, four PCLs were developed for use in the FS Report for evaluation of the remedial alternatives of sediments and soils. The reasonable potential future users within the USEPA's Preliminary Site Perimeter used in the development of alternatives include hypothetical recreational fisher and hypothetical recreational visitor for sediments, and hypothetical construction and hypothetical commercial workers for soils. Exposure assumptions for hypothetical subsistence fisher scenarios provided in the RI Report are not consistent with the anticipated future uses within USEPA's Preliminary Site Perimeter, so the PCL for that scenario was not used in the development of alternatives.

PCLs were also developed for total PCBs and arsenic for soils and sediments, and for total PCBs, arsenic, and mercury in tissue in the RI Report. Cancer based PCLs for total PCBs and arsenic were developed at the request of USEPA. However, the estimated lifetime cancer risks for all receptors from exposures to total PCBs and arsenic did not exceed the upper bound of the cancer risk of 1×10^{-4} that USEPA regards as acceptable outlined in the Exposure Assessment Memorandum (EAM) and the BHHRA. Also, an evaluation of PCBs and mercury concentrations in soils/sediments was presented in the RI Report, and it was concluded that the PCB concentrations are not highly elevated and contribute very little dioxin-like toxicity. Moreover, concentrations of each dioxin-like PCB congener in sediments were either significantly correlated with concentrations of TCDD and TCDF (Integral 2011), indicating that remediation for dioxins and furans will also address these PCBs (Anchor QEA and Integral 2010a, Appendix C), or were generally below detection limits. The elevated mercury concentrations in the soils on the upland sand separation area are higher than in the wastes within the Northern Impoundments, indicating that elevated mercury concentrations are not related to paper mill waste. Therefore, the evaluation of remedial alternatives is focused on the PCLs for $TEQ_{DF,M}$.

The $TEQ_{DF,M}$ PCL for sediment outside the footprint of the TCRA cap is based on exposure to dioxins and furans by a hypothetical recreational visitor, as evaluated in the BHHRA. For a noncancer hazard quotient equal to 1[2], the $TEQ_{DF,M}$ concentration in sediment for this PCL is 220 nanograms per kilogram (ng/kg) (Integral and Anchor QEA 2013a). Although the PCL for the hypothetical recreational fisher would also be appropriate, the PCL for the hypothetical recreational visitor is more conservative. Figures 3-1 and 3-2 present $TEQ_{DF,M}$ concentrations in surface and subsurface sediment, respectively, outside the footprint of the TCRA cap. The measured $TEQ_{DF,M}$ concentrations in sediments exceeded this PCL in only

[2] The noncancer $TEQ_{DF,M}$ PCL is always lower than the PCL for the cancer endpoint for any given media and exposure scenario, and is therefore the more conservative PCL (see RI Report Tables 5-29 and 5-31).

one location, northwest of the TCRA Site near the upland sand separation area, in two subsurface sample intervals at depths of 4 and 6 feet below ground surface.

The PCL for soil/sediment within the footprint of the TCRA is based on the reasonable future use of this area, which is industrial or commercial. A PCL was derived as presented in the May 14, 2013 letter (Anchor QEA 2013) for a hypothetical future outdoor commercial worker assumed to be exposed to soil/sediment in the TCRA footprint. For a noncancer hazard quotient equal to 1, the PCL as a $TEQ_{DF,M}$ concentration in soil/sediment is 1,300 ng/kg. Figures 3-3 and 3-4 present $TEQ_{DF,M}$ concentrations in surface and subsurface sediment, respectively, within the footprint of the TCRA cap relative to this PCL.

The PCL for soil within USEPA's Preliminary Site Perimeter is based on exposure to dioxins and furans by a hypothetical future recreational visitor, as evaluated in the BHHRA. For a noncancer hazard quotient equal to 1, the $TEQ_{DF,M}$ concentration in soil for this PCL is 1,300 ng/kg (Integral and Anchor QEA 2013a). The measured $TEQ_{DF,M}$ concentrations in surface soils do not exceeded this PCL in any locations outside of the TCRA footprint.

For soil in the area south of I-10, a PCL was derived based on the reasonable maximum exposure scenario for a hypothetical future construction worker. For a noncancer hazard quotient equal to 1 the $TEQ_{DF,M}$ PCL for soil is 450 ng/kg (Integral and Anchor QEA 2013a). The development of the PCL considers exposure to soil through the total depth interval (0 to 10 feet) to which a hypothetical future construction worker could be exposed. Figure 3-5 presents the depth-weighted average $TEQ_{DF,M}$ concentrations for the 0- to 10-foot depth interval for samples in the area south of I-10 relative to this PCL.

3.2 Remedial Action Objectives

The RAOs discussed in this section were established to support the initial development and refinement of preliminary remediation goals (PRG) during the RI/FS process and inform USEPA's selection of final remediation goals (or final clean-up levels) in the ROD.

The RAOs provided the first step in the process to define the chemicals and media to be addressed by the cleanup. The RAOs address specific exposure pathways and receptors, and provide the basis for defining PRGs. The RAOs for the areas within the USEPA's Preliminary Site Perimeter are provided below along with a brief summary of the extent to which RAOs have been addressed through implementation of the TCRA. The RI Report provides additional detail support for the development of the RAOs.

RAO 1: Eliminate loading of dioxins and furans from the former paper mill waste impoundments north and south of I-10, to sediments and surface waters of the San Jacinto River.

As outlined in the RI Report (Integral and Anchor QEA 2013a), the RACR (USEPA 2012c), and subsequent ongoing TCRA monitoring, the TCRA cap has achieved RAO 1. Groundwater and porewater monitoring of the TCRA Site demonstrate that dissolved transport and loading of dioxins and furans through these pathways has been effectively addressed (Integral and Anchor QEA 2013a).

The potential pathway for dioxin and furan loading to surface water and sediment from the possible impoundment south of I-10 described in the PSCR was surface runoff of soil particles. In comments on the Draft PSCR and on the Draft RI Report, USEPA raised concerns about migration of dissolved dioxins and furans with groundwater. The results of the RI Report indicate that $TEQ_{DF,M}$ concentrations in surface soils are below PCLs for the areas within Soil Investigation Area 4 south of I-10 and that pockets of dioxin-bearing waste are buried beneath several feet of soil; therefore, surface runoff of soil particles to surface water in this area is not an ongoing concern, and risk to hypothetical future commercial workers is also not a concern. Groundwater monitoring in the area south of I-10 also indicates that there is no potential for transport and loading of dioxins and furans to the aquatic environment through a groundwater pathway[3]. Therefore, existing conditions in the area of investigation south of I-10 are consistent with RAO 1.

[3] Groundwater sampling and data evaluation specific to this area have been conducted and a supplement to the RI Report is in preparation as described in the Sampling and Analysis Plan Addendum (Anchor QEA and Integral 2013).

RAO 2: Reduce human exposures to paper mill waste-derived dioxins and furans from consumption of fish and shellfish by remediating sediments affected by paper mill wastes to appropriate cleanup levels.

Implementation of the TCRA has substantially reduced exposures of aquatic biota to wastes from within the Northern Impoundments, and therefore has reduced potential human exposures via fish and shellfish consumption. Implementation of the TCRA has achieved these objectives through elimination of direct contact exposure for fish and shellfish to wastes in the Northern Impoundments and impacted sediments. Implementation of ICs (fencing and warning signs) have also mitigated potential human exposures to fish and shellfish within USEPA's Preliminary Site Perimeter.

RAO 3: Reduce human exposures to paper mill waste-derived dioxins and furans from direct contact with intertidal sediment by remediating sediments affected by paper mill wastes to appropriate cleanup levels.

Estimated baseline risks under hypothetical exposure scenarios that involved direct contact with all areas within the USEPA's Preliminary Site Perimeter other than the Northern Impoundments, but did not involve ingestion of fish and shellfish, were below risk and hazard thresholds of concern. Implementation of the TCRA has substantially reduced potential cancer and noncancer dioxin hazards to people within USEPA's Preliminary Site Perimeter. An analysis of post-TCRA human health risk (Appendix F to the BHHRA Report) for the hypothetical recreational visitor and hypothetical recreational fisher found that both the noncancer and cancer hazard indices were reduced to below 1 for these receptors by implementation of the TCRA. Therefore, RAO 3 has been successfully achieved through implementation of the TCRA. $TEQ_{DF,M}$ concentrations in surface sediment in all intertidal and subtidal areas outside of the TCRA Site are below applicable PCLs provided in Section 3.1.

RAO 4: Reduce human exposures to paper mill waste-derived dioxins and furans from direct contact with upland soils to appropriate cleanup levels.

The TCRA cap prevents exposure to soils containing paper mill waste within the TCRA Site unless the soil is exposed through excavation.

In the area of investigation south of I-10, the hypothetical future construction worker scenario indicated the potential for risk above thresholds considered acceptable by USEPA, due to exposure to dioxins and furans in the upper 10 feet of the soil column, in three specific locations. However, the dioxin and furan concentrations that cause the elevated exposures are in pockets of soil, each of which is at least 4 feet below the surface, and are therefore isolated from human contact as long as subsurface exposure during construction does not occur.

RAO 5: Reduce exposures of fish, shellfish, reptiles, birds, and mammals to paper mill waste-derived dioxins and furans by remediating sediment affected by paper mill wastes to appropriate cleanup levels.

Baseline risks associated with dioxins and furans to benthic macroinvertebrate communities and populations of fish, birds, mammals, and reptiles in the area north of I-10 and the aquatic environment were determined in the BERA to be negligible, except for risks to shorebirds (represented by the spotted sandpipers) and small mammals (represented by the marsh rice rat) that could live or forage in direct contact with the wastes or intertidal sediments in the impoundments north of I-10. Baseline ecological risks include reproductive risks to mollusks from exposure to 2,3,7,8-TCDD, primarily in the area of the Northern Impoundments. Baseline ecological risks elsewhere within the USEPA's Preliminary Site Perimeter were negligible, or were very low and the result of exposures to chemicals from sources other than paper mill wastes.

Analysis of post-TCRA risks to those ecological receptors that were potentially at risk under baseline conditions indicates that, because the TCRA eliminated exposures to dioxins and furans through direct ingestion of or direct contact with waste materials within the 1966 perimeter of the Northern Impoundments, the post-TCRA conditions do not pose a risk for ecological receptors. Remediation of sediments and soils within the TCRA footprint and ongoing natural recovery of sediments in areas outside of the TCRA footprint have reduced

COC concentrations in sediments, water, and biota. This RAO has been achieved through implementation of the TCRA.

3.3 Applicable or Relevant and Appropriate Requirements

The development and evaluation of remedial alternatives, as presented in Section 5 of this document, includes an assessment of the ability of the remedial alternatives to address ARARs of environmental laws and other standards or guidance to-be-considered (TBC). Table 3-1 provides a summary of potential ARARs and TBCs that are considered in this FS Report. The list in Table 3-1 includes certain citations that are not applicable to the USEPA's Preliminary Site Perimeter to document the rationale for eliminating these regulations, standards, or guidelines from consideration. Many of the ARARs and TBCs in Table 3-1 are relevant to only some of the remedial alternatives, but all of the requirements that may be relevant to any of the remedial alternatives are identified in the list. Finally, USEPA may find during its review of remedial alternatives that the most suitable remedial alternative does not meet an ARAR. The National Contingency Plan (NCP) provides for waivers of ARARs under certain circumstances (see 40 CFR 300.430(f)(1)(ii)(C)).

After a remedy is selected, a detailed review of ARARs specific to the selected remedial action will be conducted and included in the Design Analysis Report for the selected action. The implementation of the remedy generally will not require Federal, State, or local permits because of the permit equivalency of the CERCLA remedy-selection process (40 CFR 300.400(e)(i)), but remedial actions will be completed in conformance with substantive technical requirements of applicable regulations.

The ARARs in Table 3-1 can be broken out into three different categories, although some ARARs may belong to more than one of these categories:

- Chemical-specific requirements
- Location-specific requirements
- Performance, design, or other action-specific requirements

Chemical-specific ARARs are typically the environmental laws or standards that result in establishment of health- or risk-based numerical values. When more than one of these chemical-specific ARARs are applicable to site-specific conditions, a remedial alternative should generally comply with the most stringent or conservative ARAR. Chemical specific ARARs presented in Table 3-1 include Clean Water Act (CWA) criteria and State water quality and waste standards. The development of PCLs within the USEPA's Preliminary Site Perimeter considered chemical-specific ARARs, as well as other generally accepted benchmarks for protection of human health and the environment.

Location-specific ARARs include restrictions placed on concentrations of hazardous substances or the implementation of certain types of activities based on the location of a site. Some examples of specific locations include floodplains, wetlands, historic places, land use zones, and sensitive habitats. Location-specific ARARs presented in Table 3-1 include the Rivers and Harbors Act, Coastal Zone Management Act, and Federal Emergency Management Agency/National Flood Insurance Program regulations.

The action-specific ARARs are generally technology or activity-based limitations or guidelines for management of pollutants, contaminants, or hazardous wastes. These ARARs are triggered by the type of remedial activity selected to achieve the RAO and these requirements may indicate how the potential alternative must be achieved. Action-specific ARARs presented in Table 3-1 include CWA water quality certifications (Section 401) and discharges of dredged and fill material (Section 404), Clean Air Act, Endangered Species Act (ESA), and other wildlife protection acts.

The following sections discuss ARARs that have the most significance to the evaluation of remedial alternatives for the USEPA's Preliminary Site Perimeter. Action-specific ARARs do not apply to all of the remedial alternatives. For example, requirements for waste management and hazardous materials transportation are most significant for remedial alternatives that involve removal of sediment, and would not apply at all to remedial alternatives that do not include removal of material from within the USEPA's Preliminary Site Perimeter. The types of actions that would trigger compliance with these requirements are also discussed.

3.3.1 Water Quality and Water Resources

3.3.1.1 Section 303 and 304 of the Clean Water Act and Texas Surface Water Quality Standards

Section 303 of the CWA requires states to promulgate standards for the protection of water quality based on Federal water quality criteria. Federal water quality criteria are established pursuant to Section 304. Texas Surface Water Quality Standards are relevant to the evaluation of short-term and long-term effectiveness of the remedial alternatives.

Demonstration of substantive compliance with these ARARs will be achieved using:

- Best management practices (BMPs) incorporated into the design to support water quality and attainable use standards for this section of the San Jacinto River. These BMPs include the use of silt fences to manage potential upland runoff, plastic sheeting to cover any required upland stockpiles, and other erosion control measures to be described in the plans and specifications of the final remedy.
- Water quality monitoring, performed as described in the Water Quality Monitoring Plan that will be developed to detect potential impacts on water quality and trigger the implementation of additional BMPs or an interruption of construction if necessary.

3.3.1.2 Section 401 Water Quality Certification of the Clean Water Act as Administered by Texas

Section 401 requires that the applicant for federal permits obtain certification from the appropriate state agency that the action to be permitted will comply with state water quality standards. Although environmental permits are not required for on-site CERCLA response actions, the selected remedy will incorporate elements to comply with State water quality standards. Consultation with the TCEQ may be necessary to confirm that the final design of the selected alternative meets the substantive requirements of Section 401 of the CWA.

Documentation of substantive compliance with this ARAR would include:

- Coordinating with TCEQ regarding the information required in the Section 401 "Tier 2" Water Quality Certification questionnaire and incorporating agency feedback in the design, if needed

- Providing documentation of the consultation to USEPA

3.3.1.3 Section 404 and 404 (b)(1) of the Clean Water Act

Section 404 requires that discharges of fill to waters of the United States serve the public interest. In selecting a remedial alternative including discharge of fill, USEPA would be required to make the determination that the placement of materials into the San Jacinto River serves the public interest as necessary to remediate source material from within the USEPA's Preliminary Site Perimeter.

The area within the USEPA's Preliminary Site Perimeter includes wetlands in the area north of I-10, and a plan will need to be established that addresses the requirements (to the extent practicable) of Section 404 and 404(b)(1). The Respondents previously prepared a potentially jurisdictional waters of the U.S. (including wetlands) report (Anchor QEA 2010; Anchor QEA 2011a) as part of the TCRA implementation in compliance with the 1987 U.S. Army Corps of Engineers (USACE) Wetlands Delineation Manual and Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coastal Plan Region. A supplemental draft 404(b)(1) report may need to be prepared for consideration by USEPA depending on the nature of the selected remedy.

Specific BMPs anticipated to be included in construction actions, if necessary to minimize the impacts of discharges of fill into the water, include:

- The use of a silt curtains and debris booms around in-water work areas
- The use of upland erosion controls such as plastic covering of stockpiles
- The use of silt fencing around upland areas
- Construction of a stable upland haul route capable of handling construction traffic without creating ruts that would develop into a source of turbid water
- Monitoring and maintenance during construction to ensure these BMPs are functioning as designed

3.3.1.4 Texas Pollutant Discharge Elimination System

Within the State of Texas, the National Pollutant Discharge Elimination System (NPDES), which demonstrates compliance with Section 402 of the CWA, is administered by TCEQ and referred to as Texas Pollutant Discharge Elimination System (TPDES). To demonstrate substantive compliance with TPDES, the following measures will be taken:

- The contractor will be required to prepare a Storm Water Pollution Prevention Plan (SWPPP) in accordance with the general permit requirements of TXR150000 (the TPDES permit for construction activities).
- The contractor will be required to implement appropriate monitoring during construction.

3.3.1.5 Rivers and Harbor Act and Texas State Code Obstructions to Navigation

The USEPA's Preliminary Site Perimeter is within a navigable waterway, and the State of Texas regulates the obstruction of navigable waters within the State involving the construction of structures, facilities, and bridges or removal and placement of trees that would obstruct navigation (TPWD 2008). The State of Texas considers land within the bed and banks of rivers to be public and requires access for the public to such areas. With the exception of the TCRA Site, which is required to be restricted to minimize the potential for disturbance of the armored cap by vehicular traffic or vandalism, the remedial alternatives will not limit public access.

Documentation of compliance with this ARAR would entail documenting, with State concurrence, the extent to which a remedial alternative would affect navigability of the San Jacinto River in the vicinity of the USEPA's Preliminary Site Perimeter.

3.3.2 Protected Species Requirements

This section addresses requirements of the ESA, the Fish and Wildlife Coordination Act, the Bald and Golden Eagle Protection Act, and the Migratory Bird Treaty Act. The area within the USEPA's Preliminary Site Perimeter surrounds a section of a major highway including an overpass; however, the USEPA's Preliminary Site Perimeter is upstream of Galveston Bay, which provides rearing, spawning, and adult habitat for numerous marine and estuarine fish and invertebrate species including blue crab, drum, flounder, oysters, spotted sea trout, and shrimp. Sea turtles, including the Federally listed green, hawksbill, Kemp's Ridley, leatherback, and loggerhead turtles occasionally enter Galveston Bay to nest and feed National Oceanic and Atmospheric Administration (NOAA 2010a). The National Marine Fisheries Service (NMFS) includes the ESA-listed sea turtles in Trust resources, but these turtles are not likely to be present within the USEPA's Preliminary Site Perimeter. The design and overall goal of the remedial action is to improve habitat conditions through the anticipated reduction of potential exposure to COCs.

To address concerns regarding presence of protected species, the Respondents retained a qualified biologist to conduct a threatened and endangered species (TES) survey. The TES survey led to a determination that there is no likely presence of protected species and their habitat within the USEPA's Preliminary Site Perimeter (Anchor QEA 2010a). Moreover, the BERA concluded that under baseline and post-TCRA conditions, there is no risk to the protected species that were evaluated.

Further documentation of compliance with the protected species requirements would include:

- Incorporation of BMPs into the design to prevent or minimize incidental construction-related releases that could potentially impact protected species off-site.
- Pursuant to CERCLA Section 121(e) and USEPA policy, consultation with the U.S. Fish and Wildlife Services (USFWS) and NMFS is needed to confirm that the implementation of the proposed remedy will have no effect on listed species or habitat.

3.3.3 Coastal Zone Management Act and Texas Coastal Management Plan

Federal agency activities that have reasonably foreseeable effects on any land or water use or natural resource of the coastal zone (also referred to as coastal uses or resources and coastal effects) must be consistent to the maximum extent practicable with the enforceable policies of a coastal State's Federally approved coastal management program (NOAA 2010b). The Texas General Land Office (GLO) administers the Texas Coastal Management Consistency certification process.

Substantive compliance with the certification would be demonstrated by:

- Evaluating the effects of the proposed remedy on critical areas (if any) and associated criteria including no net loss of critical area functions and values.
- Evaluating the remedy for compliance with the Texas Coastal Zone Management Consistency Determination and policies identified in the application for Consistency with the Texas Coast Management Program.
- Supporting the USEPA's consultation with the Galveston District USACE and Texas GLO.

3.3.4 Floodplain

A hydrologic evaluation (Appendix B) subject to USEPA approval was performed to evaluate the impacts of the remedial alternatives on the water levels in the San Jacinto River. The evaluation of potential effects of the remedial alternatives on flooding is discussed in the detailed evaluation of the remedial alternatives in Section 5. USEPA's review of the FS Report and selection of the remedy will consider whether the placement of fill will significantly affect water levels within the floodplain of the San Jacinto River.

3.3.5 Cultural Resources Management

No historic properties eligible for listing in the National Register of Historic Places (NRHP) are recorded within the USEPA's Preliminary Site Perimeter (Anchor QEA and Integral 2010a).

3.3.6 Noise Control Act

Noise abatement may be required if actions are identified as a public nuisance. Due to the TCRA Site being bounded by water on three sides and adjacent to a highway overpass on the fourth side, noise from the construction activity is unlikely to constitute a public nuisance. If necessary, BMPs would be implemented to reduce the noise levels. If materials are delivered to or removed from the project area by truck, noise greater than 60 decibels in close proximity to sensitive receptors (schools, residential areas, hospitals, and nursing homes) will be avoided. Truck routes will be selected to avoid sensitive receptors to the extent possible.

3.3.7 Hazardous Materials Transportation and Waste Management

Remedial alternatives 5 and 6 (presented in Section 4) include removal of sediments exceeding PCLs and transportation of the sediment to an off-site disposal facility. Off-site disposal would also be required for limited quantities of waste, such as used personal protective equipment and any debris or vegetated materials required to be removed during clearing and grading activities, associated with all of the remedial alternatives except for no further action (Alternative 1). The contractor will be required to package any hazardous materials in appropriate containers and label containers in accordance with Texas Department of Transportation requirements. The development of remedial alternatives anticipates that all disposal will be at a permitted facility (e.g., landfill and/or incinerator). If an off-site facility needs to be established for dewatering sediment or transloading waste from barges to trucks or rail cars, it may require a solid waste permit.

4 DEVELOPMENT OF REMEDIAL ALTERNATIVES

The RAM (Anchor QEA 2012b) describes the identification of General Response Actions (GRAs) and the screening of remedial technologies. In addition, the RAM describes the development of a set of preliminary remedial alternatives, including a No Further Action alternative and remedial alternatives focused on removal or a combination of removal, treatment, and containment to achieve a range of post-remedy SWACs.

The preliminary remedial alternatives were modified in discussions with USEPA Region 6 subsequent to submittal of the RAM for a number of reasons. Most significantly, PCLs not available when the RAM was prepared have been developed for sediment and soil as described in Section 3.1. Based on a comparison of $TEQ_{DF,M}$ concentrations in sediment and soil to the PCLs, areas of affected sediment and soil potentially subject to remedial action have been identified and are discussed in the descriptions of the remedial alternatives in the following subsections. The remedial alternatives developed for the FS in coordination with USEPA Region 6 include:

- Alternative 1 – No Further Action
- Alternative 2 – Institutional Controls ("ICs") and Monitored Natural Recovery ("MNR")
- Alternative 3 – Permanent Cap, ICs, and MNR
  Alternative 4 – Partial Solidification/Stabilization, Permanent Cap, ICs, and MNR
- Alternative 5– Partial Removal, Permanent Cap, ICs, and MNR
- Alternative 6 – Full Removal of Materials Exceeding the Protective Concentration Level, ICs, and MNR

A brief description of the primary elements for each alternative is provided in the remainder of this section, and Table 4-1 provides a summary of the quantities of materials that may be used and durations associated with each of the alternatives.

Following the general descriptions of alternatives provided in the remainder of this section, Section 5 provides a detailed evaluation of the remedial alternatives with consideration of each of the criteria required by the NCP, 40 CFR Section 300.430(e)(9). Those criteria include overall protection, compliance with ARARs, long-term effectiveness, reduction of toxicity, mobility, or volume (TMV), short-term effectiveness, implementability, cost, State acceptance, and community acceptance. USEPA Region 6 Clean and Green Policy (USEPA 2009c) was also considered in the development of all of the alternatives.

4.1 Alternative 1 – No Further Action

The No Further Action alternative serves as the baseline of comparison for the other remedial alternatives. The NCP requires the development and evaluation of the No Further Action alternative (40 CFR 300.430(e)(6)). As described in Section 2, the TCRA included capping the TCRA Site, installing a security fence, and posting warning signs. In the area of investigation south of I-10, soil exceeding PCLs is buried under at least 2 feet of surface soil (Figure 2-5). Under the No Further Action alternative, the controls installed as part of the TCRA would be left in place and no additional remedial action would be implemented. Ongoing inspection and maintenance of the TCRA would be performed in accordance with the USEPA-approved OMM plan.

In the area of the TCRA Site, the $TEQ_{DF,M}$ SWAC for soil/sediment following completion of the TCRA is approximately 12 ng/kg dry weight, which is well below the PCL for hypothetical recreational visitors (220 ng/kg). No surface soil/sediment samples under current conditions have a $TEQ_{DF,M}$ concentration exceeding this PCL (Figure 3-1). The only sediment samples outside of the limits of the TCRA cap with $TEQ_{DF,M}$ concentrations exceeding the PCL for hypothetical recreational visitors are two subsurface sediment samples collected north of I-10 from one location near the upland sand separation area, and these samples are buried beneath at least 3 feet of sediment with $TEQ_{DF,M}$ concentrations below the PCL.

For locations within the area of investigation south of I-10, the arithmetic mean of $TEQ_{DF,M}$ concentrations in surface soil is 13.3 ng/kg dry weight, which is well below the PCL for a hypothetical outdoor commercial worker (1,300 ng/kg). The highest $TEQ_{DF,M}$ concentration observed in surface soil, 36.9 ng/kg, is also well below this PCL.

In subsurface soil (6 to 24 inches below grade), the average $TEQ_{DF,M}$ concentration is 16.5 ng/kg. The highest $TEQ_{DF,M}$ concentration observed in subsurface soil is 303 ng/kg. In the top 10 feet of subsurface soil in the area of investigation south of I-10, 20 samples in 12 cores were found to have $TEQ_{DF,M}$ concentrations greater than the soil PCL, but depth weighted average $TEQ_{DF,M}$ concentration in the upper 10 feet of soils exceeded the PCL for this receptor in four locations. The PCL for the hypothetical future construction worker is based on exposure assumptions that include contact with the soil interval from the surface to 10 feet below grade. Therefore, the PCL should be compared to the average soil concentration in the top 10 feet of soil, which is how the data are presented in Figure 3-5.

This alternative includes ongoing OMM of the TCRA cap, which includes inspection and periodic maintenance. The estimated cost of this alternative is $1.3 million (Appendix C).

4.2 Alternative 2 – Institutional Controls and Monitored Natural Recovery

ICs are administrative measures that are implemented to mitigate risks or to protect the integrity of engineered controls. ICs include "Proprietary Controls," which are restrictions placed on the use of private property, "Governmental Controls," which include restrictions on the use of public resources, "Enforcement Tools" that may be imposed by an agency to compel certain actions, and "Informational Devices," which include notices about the presence of contamination or fishing advisories (USEPA 2012a).

Under this remedial alternative, the following ICs would be implemented:

- Restrictions on dredging and anchoring would be established to protect the integrity of the TCRA cap and to limit potential disturbance and resuspension of buried sediment near the upland sand separation area where one location exists with $TEQ_{DF,M}$ concentrations exceeding the sediment PCL.
- Deed restrictions would be applied in the area of investigation south of I-10 where the depth weighted average $TEQ_{DF,M}$ concentrations in upper 10 feet of subsurface soil exceed the soil PCL for the hypothetical future construction worker.
- Notices would be attached to deeds of affected properties to alert potential future purchasers of the presence of waste and soil with $TEQ_{DF,M}$ concentrations exceeding the soil PCL.
- Public notices and signage around the perimeter of the TCRA Site would be maintained or provided, as appropriate.

A periodic sampling and analytical program would be implemented to monitor the progress of natural recovery. Modeling, presented in Appendix A, projects that ongoing sedimentation will reduce $TEQ_{DF,M}$ concentrations in surface sediment over time. Specifically, natural recovery from sediment inputs within the USEPA's Preliminary Site Perimeter is predicted to further reduce the SWAC for 2,3,7,8-TCDD and 2,3,7,8-TCDF within the USEPA's Preliminary Site Perimeter by a factor of two over a period of 10 to 15 years. The estimated cost for this alternative is $1.6 million (Appendix C).

4.3 Alternative 3 – Permanent Cap, Institutional Controls, and Monitored Natural Recovery

The TCRA cap was constructed to provide immediate containment of the materials in the TCRA Site. As required in USEPA's Action Memorandum for the TCRA (USEPA 2010a, Appendix A), the containment method was chosen to be compatible with the final remedy and meet applicable design criteria for degree of safety. As with any design, the degree of safety can be increased. For the TCRA cap, that would involve flattening the slopes of the existing TCRA cap by adding additional armor rock material to enhance the effectiveness and permanence of the armored cap remedy by increasing the degree of safety for the armor rock design, to create a permanent cap.

The TCRA cap was originally designed with a robust armor layer to provide reliable containment of materials exceeding PCLs in the Northern Impoundments. As described in Appendix B, armor materials were sized using a factor of safety of 1.3, which is greater than the suggested minimum of factor of safety of 1.1 to provide additional protection of the Northern Impoundments against catastrophic failure.

The Permanent Cap adds further robustness to the TCRA cap design by using an even higher factor of safety of 1.5 for sizing the armor stone, and by flattening submerged slopes from 2 horizontal to 1 vertical (2H:1V) to 3 horizontal to 1 vertical (3H:1V) and flattening the slopes in the surf zone from 2H:1V to 5 horizontal to 1 vertical (5H:1V). In addition, the Permanent Cap uses rock sized for the "No Displacement" design scenario, which is more conservative than the "Minor Displacement" scenario used for the TCRA cap design, as well as other CERCLA caps, such as Onondaga Lake and Fox River (Appendix B).

The anticipated extent of the additional rock that would be placed during construction of a permanent cap is shown on Figures 4-1 and 4-2, and would entail construction of 5H:1V slopes along the central, western and southern berms, and 3H:1V slopes over the submerged portion of the Northwestern Area, requiring placement of approximately 3,400 cy of armor rock. Based on the production rates that were realized during TCRA construction, the duration of construction for this alternative is estimated to be 2 months (Table 4-1). During construction of the TCRA, obtaining access to the work area from the uplands was a demonstrated implementability challenge; construction of Alternative 3 will require access from the uplands be obtained, and obtaining such access could be a challenge. This alternative is estimated to require 750 hours of heavy equipment operations, resulting in greenhouse gas, PM, and ozone-generating emissions, and more than 250 truck trips causing greenhouse gas, PM, and ozone-generating emissions, as well as traffic impacts (Table 4-2). Equipment and vehicle emissions of hydrocarbons and nitrogen oxides lead to the generation of smog, including ozone, which is a particular concern in Harris County which has been classified by USEPA as a "severe" non-attainment area for the 1997 8-hour ozone standard and a "moderate" non-attainment area for the 2008 8-hour ozone standard. Moreover, Harris County has not yet been classified for the 2012 fine partical particulate matter ($PM_{2.5}$) annual National Ambient Air Quality Standard (TCEQ 2013). Using construction worker injuries and fatality rates published by the U.S. Department of Labor (USDL 2011), Alternative 3 is estimated to result in nearly 0.15 lost time injuries, and more than 0.0005 fatalities as a result of construction (Table 4-3). Although both of these safety statistics are below 1.0, they are useful for comparison purposes to the safety-related issues of the other alternatives. Further discussion of this comparison is provided in Section 6. The cost of this alternative is estimated to be $2.9 million (Appendix C).

Surface flow and wave break modeling was performed to evaluate potential erosive forces to support the selection of cap materials to resist those forces (Appendix B). The modeling considers wind and vessel generated waves breaking in the surf zone, as well as river currents under a variety of design storm and flood scenarios. This modeling is described in more detail in Appendix B. ICs and MNR, as described in Section 4.2, are also included in this remedial alternative.

4.4 Alternative 4 – Partial Solidification/Stabilization, Permanent Cap, Institutional Controls, and Monitored Natural Recovery

This remedial alternative is included per the direction of USEPA Region 6 to address material that exceeds 13,000 ng/kg $TEQ_{DF,M}$ within the USEPA's Preliminary Site Perimeter. The extent of the area for partial solidification/stabilization (S/S) was defined, based on sediment and soil chemistry results presented in the RI Report, as the Western Cell and a portion of the Eastern Cell of the TCRA Site that is currently covered by the TCRA cap. The maximum depth of S/S in the Western Cell would be approximately 10 feet based on the analysis of sediment core samples presented in Figure 2-4. A permanent cap, ICs, and MNR, as described in Sections 4.2 and 4.3, are also included in this remedial alternative.

Figure 4-3 presents a plan view of the partial S/S remedial alternative. Figure 4-4 presents a cross section of this remedial alternative to give a typical representation of the depth of S/S. S/S treatment could be accomplished using large-diameter augers or conventional excavators, similar to those that were used to treat portions of the sediment in the Western Cell during the TCRA. Both technologies are discussed in the RAM. Before treating the sediment, the affected portions of the TCRA cap armor rock would need to be removed and stockpiled for reuse, if possible, or washed to remove adhering sediment and disposed in an appropriate upland facility. The geotextile and geomembrane would need to be removed and disposed of as contaminated debris. S/S reagents—which could include Portland cement, lime, fly or bottom ash, or a combination of these materials—would be delivered to the project work area, stockpiled, and mixed with sediment, as needed, to treat the sediment in situ. Following treatment, the treated sediment would be re-capped with a permanent cap as described in Alternative 3. Submerged areas that would be stabilized would need to be isolated from the surface water with sheetpiling and mostly dewatered prior to mixing with treatment reagents. Following completion of the S/S operation, the existing protective cover (including the armor cap, geotextile and geomembrane barriers) would be replaced and then the permanent cap, as described in Alternative 3, would be constructed.

The estimated footprint of this alternative is approximately 2.6 acres in the Western Cell and 1.0 acre of submerged sediment spanning the Eastern Cell and the Northwestern Area (Figure 4-3). Based on the horizontal and vertical limits identified for this alternative, a total of approximately 53,300 cy of soil and sediment would be treated. Following treatment, replaced permanent cap would be constructed in the areas of treatment. Using production rates similar to that achieved during the TCRA, this alternative has an estimated construction duration of 15 months (Table 4-1). As with Alternative 3, access to the work area from the uplands will be required and could be a challenge. This alternative is estimated to require almost 6,000 hours of heavy equipment operations, and more than 1,500 truck trips causing higher greenhouse gas, PM, and ozone-generating emissions and traffic impacts (Table 4-2) than the previous three Alternatives. Alternative 4 is estimated to result in more than one lost time injury, and nearly 0.005 fatalities as a result of construction (Table 4-3). The cost of this alternative is estimated to be $11.2 million (Appendix C).

4.5 Alternative 5 – Partial Removal, Permanent Cap, Institutional Controls, and Monitored Natural Recovery

This remedial alternative is also included as directed by USEPA Region 6 and involves removing sediments/soils that exceed 13,000 ng/kg $TEQ_{DF,M}$ from areas of the TCRA Site that are currently contained by the TCRA cap. The lateral and vertical extent and volume of sediment removed under the action is the same as the sediment to be treated as described in the previous section for Remedial Alternative 4 and is depicted on Figures 4-5 and 4-6. Under this alternative, submerged areas would need to be isolated using a turbidity barrier/silt curtain prior to excavating sediment. Construction of a permanent cap, ICs, and MNR, as described in Sections 4.2 and 4.3, are also included in this remedial alternative.

As documented in the RAM (Anchor QEA 2012b), all dredging projects result in some degree of resuspension, release, and residuals (NRC 2007). The need to address residual contamination following dredging depends upon the concentrations and thicknesses of residuals remaining. However, empirical data from numerous sediment remediation projects indicate that residual contamination is a common occurrence and that sites with high concentrations are unlikely to achieve RALs with dredge technology alone (Patmont and Palermo 2007; NRC 2007). Further, case studies have shown that engineering controls used to control impacts from dredging such as sheetpiles may have limited effectiveness (Anchor Environmental 2005; Anchor QEA and Arcadis 2010) and can pose unintended consequences, such as concentration of dissolved-phase chemicals, localized scour adjacent to the barrier, and/or the spread of contaminants during their removal (Anchor QEA and Arcadis 2010; Konechne et al. 2010; Ecology 1995).

Upland areas would not need to be isolated with sheetpiling, but the excavation would require continuous dewatering and may need to be timed to try to avoid high water and times of year when storms are most likely.

Excavated sediment would be dewatered and potentially treated to eliminate free liquids prior to transporting it for disposal. Effluent from excavated sediment dewatering would need to be handled appropriately, potentially including treatment prior to disposal. Depending on the availability of a suitable disposal facility and their acceptance of the waste, some portion of the excavated material could require incineration as part of the disposal process. Following completion of the excavation, the work area would be backfilled to replace the excavated sediment, the existing protective cover (including the armor cap, geotextile and geomembrane barriers) would be replaced and then the permanent cap, as described in Alternative 3, would be constructed.

The construction duration for this alternative is estimated to be 12 months (Table 4-1). This alternative is estimated to require almost 7,000 hours of heavy equipment operations and more than 9,000 truck trips causing higher greenhouse gas and PM emissions, ozone generation, and traffic impacts (Table 4-2) as compared to the previous four alternatives. As with Alternatives 3 and 4, access to the work area from the uplands will be required and could be a challenge. Off-site transport of materials for disposal presents a risk for spills and accidents, which could result in exposure of these materials to the general public. Alternative 5 is estimated to result in more than one non-fatal lost time injury, and more than 0.005 fatalities as a result of construction (Table 4-3). The cost of this alternative is estimated to range from $24 to $118 million, depending on the need for incineration as part of the disposal process (Appendix C).

4.6 Alternative 6 – Full Removal of Materials Exceeding the PCL, Institutional Controls, and Monitored Natural Recovery

For the full removal alternative, the hypothetical recreational visitor exposure scenario was considered for the area within the TCRA cap. The PCL for protection of the hypothetical recreational visitor is a $TEQ_{DF,M}$ concentration of 220 ng/kg.

The lateral and vertical extents of the removal under this remedial alternative are presented in Figures 4-7 and 4-8. As with the partial removal alternative, cap rock and geotextile would need to be removed prior to beginning excavation within the TCRA footprint, upland excavation could require dewatering to allow excavation of impacted sediment in relatively dry conditions, and excavation of submerged sediment would require isolation of the work area with a turbidity barrier/silt curtain. Excavated sediment would be further dewatered and stabilized at the offloading location, as necessary, to eliminate free liquids for transportation and disposal. Following removal of impacted sediment, the area from which sediments are removed would be covered with a residuals management layer of clean sediment. This alternative also includes ICs, which would be implemented for specific areas south of I-10, and continuing natural recovery of sediments within the river.

This alternative entails removal of approximately 208,300 cy of sediment from the TCRA footprint and the area near the upland sand separation area, which would require a relatively large offloading and sediment processing facility to efficiently accomplish the work. Alternative 6 is estimated to have a construction duration of 16 months (Table 4-1). Locating an adjacent facility with sufficient space and availability for more than a year of use for staging, offloading, and sediment processing is considered to be a significant challenge to the implementability of Alternative 6. This alternative is estimated to require over 15,000 hours of heavy equipment operations, and over 18,000 truck trips causing significantly higher greenhouse gas and PM emissions, ozone generation, and traffic impacts (Table 4-2) as compared to the previous five alternatives. Off-site transport of materials for disposal presents a significantly higher risk for spills and accidents compared to Alternative 5, which could result in exposure of these materials to the general public. Dewatering by using additive drying amendments such as lime or Portland cement could result in significant fugitive dust emissions at the offloading/processing area.

Alternative 6 is estimated to result in more than three lost time non-fatal injuries, and more than 0.01 fatalities as a result of construction (Table 4-3). The cost of this alternative is estimated to range from $104 to $636 million, depending on the need for incineration as part of the disposal process (Appendix C).

5 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

As discussed in Section 4, the detailed evaluation of remedial alternatives is based on consideration of the following criteria, as required by the NCP, 40 CFR Section 300.430(e)(9):

1. Overall protection
2. Compliance with ARARs
3. Long-term effectiveness
4. Reduction of TMV
5. Short-term effectiveness
6. Implementability
7. Cost
8. State acceptance
9. Community acceptance

The first two criteria, overall protection and compliance with ARARs, are identified as threshold criteria in 40 CFR Section 300.430(f). Remedial alternatives must satisfy the threshold criteria to be selected as the final remedy, although ARAR waivers are considered in some circumstances. The next five criteria are identified as primary balancing criteria. The comparative analysis considers the anticipated performance of the remedial alternatives relative to these balancing criteria. The final two criteria, identified as modifying criteria, are considered by USEPA in preparing the ROD based on consultation with the State environmental agency and public comments received in response to the FS Report and the proposed plan. Item 39 of the Statement of Work attached to the UAO states that the modifying criteria are not to be considered in the comparative analysis in this FS Report. Information related to the modifying criteria are therefore not provided in this section.

The first seven criteria, as presented in 40 CFR 300.430(f), are briefly defined below:

- *Overall protection* is an evaluation of whether the remedial alternative can adequately protect human health and the environment. This may be expressed as an assessment of whether the remedial alternative addresses all of the RAOs, which are identified and described in Section 2.
- *Compliance with ARARs* is an evaluation of whether the remedial alternative

addresses or can be implemented in compliance with all of the ARARs, which are identified in Table 3-1.

- *Long-term effectiveness* is an evaluation of the ability of the remedial alternative to reliably maintain protection of receptors.
- *Reduction of TMV* is an evaluation of the degree to which treatment or recycling of affected media is used to reduce the toxicity, mobility, or volume of contaminated media, particularly principal threats.
- *Short-term effectiveness* is an evaluation of both the time required for the remedial alternative to achieve full protection and the degree to which potential risk to human health and the environment is increased during implementation of the remedy, considering measures that may be used to mitigate short-term risks. The short-term effectiveness evaluation also includes an evaluation of the sustainability of the remedial alternative in conformance with the USEPA Region 6 Clean and Green Policy (USEPA 2009c).
- *Implementability* is an evaluation of factors that may impede the implementation of the remedy, considering technical and administrative factors. Technical factors include consideration of whether the remedial alternative involves the use of well demonstrated technologies, readily available equipment and materials, and whether any physical conditions of the project work area may impede implementation. Administrative factors include consideration of whether implementation of the remedial alternative might be impeded by the need to obtain approvals from nearby landowners or public agencies.
- *Cost* is an evaluation of construction and long-term operation, maintenance, and monitoring costs. A present-worth cost analysis is typically used to evaluate the total cost of remedial alternatives.

This section describes the individual analyses for each of the alternatives. Table 5-1 summarizes the key discussion points from this section for each of the evaluation criteria.

5.1 Alternative 1 – No Further Action

5.1.1 Threshold Criteria

The No Further Action remedial alternative would be protective of human health and the environment. As discussed in Section 2.6, other than locations capped during the TCRA, the only sediment samples with $TEQ_{DF,M}$ concentrations exceeding the applicable PCLs are located within a small area of subsurface sediment near the upland sand separation area. The subsurface sediment near the upland sand separation area is isolated from potential receptors by several feet of sediment with $TEQ_{DF,M}$ concentrations below the PCL for hypothetical recreational visitors. Model predictions presented in Appendix A indicate that net erosion depths during extreme flood events will be limited to less than 15 centimeters in this area, and that over the long-term, ongoing deposition will result in declines in surface sediment concentrations in this area. However, disturbance from propeller wash, for example, due to activities from the adjacent SJRF operations, could cause locally greater erosion that that modeled for extreme flood events depending on the water depth, the size of the vessel, and the duration of vessel operations. Sediment in the footprint of the TCRA cap is also isolated from exposure at the surface by layers of geotextile, geomembrane, and cap rock. Soil from areas of investigation south of I-10 that exceeds the PCL for hypothetical future construction workers is isolated from the surface by several feet of soil with $TEQ_{DF,M}$ concentrations below this PCL.

Alternative 1 would not result in construction impacts or other changes to baseline conditions that would trigger any action or location-specific ARARs identified in Table 3-1. The fate and transport model described in Appendix A predicts significant improvements in water quality within the USEPA's Preliminary Site Perimeter as a result of the TCRA cap. Under these post-TCRA conditions, there are no documented exceedances of surface water quality standards within the USEPA's Preliminary Site Perimeter due to the presence of dioxins and furans, even though there are ongoing external sources from atmospheric deposition, upstream sediment loads, stormwater runoff and point source discharges. Therefore, the continuation of post-TCRA conditions is expected to result in ongoing water quality compliance.

5.1.2 Balancing Criteria

The long-term effectiveness of this remedial alternative was evaluated considering the potential for natural forces or human activity to expose the sediment or soil with $TEQ_{DF,M}$ concentrations that exceed the applicable PCLs. The sediment transport modeling (Appendix A) results indicate that sediment in the vicinity of the upland sand separation area is stable and net sedimentation in this area is expected to provide continued isolation at this buried location; however, propeller wash from tug boat operations associated with the SJRF operations could disturb these sediments. While the TCRA cap effectively isolates sediment in the TCRA Site from potential receptors and has been designed to resist erosive forces during extreme events in the San Jacinto River, this remedial alternative does not include alerting future landowners of the TCRA Site to the potential risks associated with activities that may involve exposing the capped sediment, and does not include placing restrictions on dredging or anchoring at the TCRA Site. Similarly, this remedial alternative does not alert landowners to the potential risks associated with certain locations in the subsurface soil in the area south of I-10.

There are no short-term risks to the community, ecological receptors, or workers associated with the implementation of this remedial alternative. The continued protection by the TCRA cap would be ensured through long-term monitoring and maintenance. There are not anticipated to be technical or administrative implementability issues associated with this remedial alternative. The estimated cost associated with this remedial alternative is $1.3 million (Appendix C) for maintaining the existing OMM plan for the TCRA cap, signs, buoys and fencing. Costs assume 20 TCRA cap monitoring events and three TCRA cap maintenance events, assuming available access to the TCRA Site from the river and through the Texas Department of Transportation (TxDOT) right-of-way (ROW). It is understood that the number of monitoring events is subject to further discussion with and approval by USEPA.

5.2 Alternative 2 – Institutional Controls and Monitored Natural Recovery

5.2.1 Threshold Criteria

This remedial alternative would achieve the RAOs through a combination of ICs, MNR, and existing engineering controls. As noted in Section 5.1, the current conditions within the

USEPA's Preliminary Site Perimeter are protective of human health and the environment. Sediment and soil with $TEQ_{DF,M}$ concentrations exceeding the applicable PCLs are isolated from potential receptors by the TCRA cap or by sediment or soil with $TEQ_{DF,M}$ concentrations below the PCLs. ICs would be used to:

- Alert property owners of the presence of subsurface materials exceeding PCLs
- Describe the need for protective equipment and training if excavation of subsurface materials exceeding PCLs is required in the TCRA footprint or specific areas south of I-10
- Describe requirements for the management of any excavated soil or sediment exceeding PCLs
- Describe the need to restore the cap or clean cover soil in these areas following any disturbance
- Establish limitations on dredging and anchoring within the footprint of the permanent cap

Affected sediment near the upland sand separation area, which is already isolated from potential receptors by several feet of sediment with $TEQ_{DF,M}$ concentrations below the PCL, would be further isolated by deposition of additional sediment through ongoing natural recovery processes as described in Section 2.6 and Appendix A. Monitoring of sediment conditions in this area would be performed to confirm that deposition of new sediment was continuing to maintain surface $TEQ_{DF,M}$ concentrations below the PCL for hypothetical recreational visitors.

Alternative 2 would involve a minimal amount of physical activity for the implementation of ICs (e.g. landowner notifications; restrictions on dredging and anchoring) and on-going implementation of existing engineering controls. For the same reasons presented in the ARAR compliance discussion under Alternative 1 (Section 5.1), due to the minimal amount of active construction involved, Alternative 2 is also expected to generally meet the substantive requirements of the ARARs presented in Section 3.4.

5.2.2 Balancing Criteria

The long-term effectiveness of this remedial alternative is primarily derived from the ICs that would protect the integrity of the TCRA cap. Long-term effectiveness is also provided by the layers of surface soil and sediments with concentrations below PCLs and the monitoring that would confirm the continued deposition of clean sediment isolating the affected sediment outside of the footprint of the TCRA cap. Long-term simulations conducted with the fate and transport model indicate the surface sediment concentrations averaged over the USEPA's Preliminary Site Perimeter are predicted to decline by a factor of two over an approximate 10- to 15-year time period (see Appendix A); monitoring would be conducted to verify actual reductions in sediment concentrations. The highest $TEQ_{DF,M}$ concentrations within the USEPA's Preliminary Site Perimeter—in the footprint of the TCRA cap and in specific areas of subsurface soil south of I-10—are isolated from potential receptors by the TCRA cap and, in the area of investigation south of I-10, by a surface layer of soil with $TEQ_{DF,M}$ concentrations well below the PCL for hypothetical construction workers.

Other than at sample locations SJSB023 and SJSB025, the highest $TEQ_{DF,M}$ concentration in the upper 2 feet of soil in the area south of I-10 is 59.3 ng/kg (Figure 2-3), which is well below the PCL of 450 ng/kg. There is no potential risk associated with the area south of I-10 other than to hypothetical future construction workers exposed to excavated soil as the $TEQ_{DF,M}$ concentrations in surface soil at all locations in the area south of I-10 are well below the PCL. The ICs would provide long-term protection against anthropogenic disturbance of the isolating barriers, cap, and clean surface soil.

There is no additional reduction of TMV due to treatment or recycling associated with this remedial alternative beyond that which was achieved during the TCRA. Risk reduction is achieved by the TCRA cap and the clean soil and sediment layers interrupting potential exposure pathways and by the use of ICs and monitoring to verify that the isolation layers remain effective.

There are no short-term risks to the community, ecological receptors, or workers associated with the implementation of this remedial alternative. The remedy would achieve full protection in the TCRA Site and the area of investigation south of I-10 immediately. As additional clean sediment continues to be deposited in aquatic areas within the USEPA's Preliminary Site Perimeter, $TEQ_{DF,M}$ concentrations in the near surface sediment interval would continue to decline and the buried sediment near the upland sand separation area with $TEQ_{DF,M}$ concentrations exceeding the PCL would be further isolated from potential receptors.

There are no technical implementability issues associated with this remedial alternative. Monitoring would involve collecting and analyzing sediment samples and evaluating the data, which are routine procedures for qualified environmental consultants and laboratories. Establishing ICs is routinely done, so there are not anticipated to be administrative implementability issues associated with this remedial alternative either.

The estimated present worth cost associated with this remedial alternative is $1.6 million (Appendix C). The capital costs for this remedial alternative are associated with preparation of sampling plans, deed restrictions and notices, and a soil management plan. The long-term costs are for collecting and analyzing environmental samples, evaluating the data, preparing reports to document the MNR, and future monitoring and maintenance of the TCRA cap. The cost estimate for this alternative assumes 20 TCRA cap monitoring events, five natural recovery monitoring events, and three TCRA cap maintenance events, and also assumes available access to the TCRA Site by water from a location along the river and by land through the TxDOT ROW. It is understood that the actual number of monitoring events will be subject to further discussion with and approval by USEPA.

5.3 Alternative 3 – Permanent Cap, Institutional Controls, and Monitored Natural Recovery

5.3.1 Threshold Criteria

This remedial alternative would achieve the RAOs through a combination of ICs, MNR, and existing engineering controls, which would be enhanced to provide greater long-term reliability and create a permanent cap. ICs would be used:

- Alert property owners of the presence of subsurface materials exceeding PCLs
- Describe the need for protective equipment and training if excavation of subsurface materials exceeding PCLs is required in the TCRA footprint or specific areas south of

I-10

- Describe requirements for the management of any excavated soil or sediment exceeding PCLs
- Describe the need to restore the cap or clean cover soil in these areas following any disturbance
- Establish limitations on dredging and anchoring within the footprint of the permanent cap

Affected sediment near the upland sand separation area, which is already isolated from potential receptors by several feet of sediment with $TEQ_{DF,M}$ concentrations below the PCL, would be further isolated by deposition of additional clean sediment as described in Section 2.6 and Appendix A. Monitoring of sediment conditions in this area would be performed to confirm that deposition of new sediment was continuing to maintain $TEQ_{DF,M}$ concentrations in surface sediments below the PCL for protection of hypothetical recreational visitors.

Implementation of Alternative 3 would also involve the placement of fill material (the additional armor rock) into the San Jacinto River to create the permanent cap. The placement of fill would trigger compliance with CWA Section 404(b)(1) and potentially other ARARs related to surface water quality standards. However, Alternative 3 is expected to generally meet the substantive requirements of the ARARs in Table 3-1 through implementation of the BMPs and the agency coordination actions outlined in Section 3.4. Construction of the permanent cap would require the placement of approximately 3,400 cy of additional cap armor rock material.

5.3.2 Balancing Criteria

The long-term effectiveness of the existing TCRA cap in this alternative is enhanced by adding additional armor rock to the cap. Flattening the slopes to create the permanent cap, as shown on Figures 4-1 and 4-2, would further enhance the structural integrity and long-term reliability of the cap. Surface flow and wave break modeling, described in more detail in Appendix B, was performed to evaluate potential erosive forces associated with a variety of storms and extreme flow events. The results of the modeling were used to confirm that the rock selected for the cap would further resist movement and provide reliable, and enhanced long-term containment of material beneath the permanent cap. This alternative is also effective over the long term because of declines in sediment surface concentrations due to natural recovery (Appendix A) throughout USEPA's Preliminary Site Perimeter. As described in Section 5.2, ICs would protect the integrity of the TCRA cap and the layer of clean surface soil. Monitoring would confirm the continued deposition of new sediment isolating the affected sediment outside of the footprint of the TCRA cap.

There is no reduction of TMV due to treatment or recycling associated with this remedial alternative beyond that achieved during the TCRA. Risk reduction is achieved by the construction of the permanent cap and the clean soil and sediment layers interrupting potential exposure pathways and by the use of ICs and monitoring to verify that the isolation layers remain effective.

Short-term risks to the community, ecological receptors, or workers associated with the implementation of this remedial alternative are limited to minimal turbidity associated with placement of armor rock, potential accidents during construction of the permanent cap, air emissions from construction equipment, and truck traffic in the community. Because of the limited duration of construction under this alternative (2 months), these risks are considered to be low: the short duration of construction is correlated with relatively low greenhouse gas, PM, and ozone-generating emissions from the construction equipment (Table 4-2). Water quality impacts from turbidity associated with placing the new armor rock are also low for this alternative because the armor rock fines that would create the turbidity would be from the rock acquired for the project and therefore not be chemically impacted. Finally, because construction work, and in particular over-water work, presents a higher risk of accidental injury or death to workers, the limited duration of this alternative results in a relatively low safety risk (Table 4-3). The remedy, like Alternatives 1 and 2, would achieve full protection in the TCRA Site and the area of investigation south of I-10 and would also occur immediately upon completion of construction. As additional sediment continues to be deposited within the USEPA's Preliminary Site Perimeter, $TEQ_{DF,M}$ concentrations in surface sediments would continue to decline to background levels (Appendix A) and the buried sediment near the upland sand separation area with $TEQ_{DF,M}$ concentrations exceeding the PCL would be further isolated from potential receptors.

There are limited implementability concerns associated with this remedial alternative. Construction of the permanent cap will require the placement of additional cap material on underwater slopes. While precise placement of material underwater is technically challenging, the feasibility of this construction technique was successfully demonstrated during the TCRA construction and experienced local contractors are available to complete this work. Monitoring would involve collecting and analyzing sediment samples and evaluating the data, which are routine procedures for qualified environmental consultants and laboratories. Although owners might object to land use restrictions, establishing ICs is routinely done, so there are not anticipated to be administrative implementability issues associated with this remedial alternative. Technical implementability issues include obtaining access to the project work area, limited availability of off-site locations for staging, material management, and barge access, and the fact that low clearance under the I-10 Bridge limits the size of marine-based equipment that can access the project work area from the water.

The estimated present worth cost associated with this remedial alternative is $2.9 million (Appendix C). The capital costs for this remedial alternative are primarily associated with the construction of the permanent cap. The costs of preparing sampling plans, deed restrictions and notices, and a soil management plan are the same as those for Alternative 2. The long-term costs are for monitoring and maintenance of the TCRA cap, collecting and analyzing environmental samples, evaluating the data, and preparing reports to document the MNR. The cost estimate for this alternative assumes 20 TCRA cap monitoring events, five natural recovery monitoring events, and three TCRA cap maintenance events, and also assumes available access to the TCRA Site by water from a location along the river and by land through the TxDOT ROW. The number of monitoring events is subject to approval by USEPA and may be changed.

5.4 Alternative 4 – Partial Solidification/Stabilization, Permanent Cap, Institutional Controls, and Monitored Natural Recovery

5.4.1 Threshold Criteria

This remedial alternative would achieve the RAOs through a combination of treatment, existing engineering controls, ICs, and MNR. S/S would be used to immobilize soil/sediment in the TCRA Site with $TEQ_{DF,M}$ concentrations above the USEPA-designated level of 13,000 ng/kg. S/S may add another level of protection to the already environmentally-protective TCRA cap. A permanent cap meeting the requirements of Alternative 3 would be re-constructed following the S/S process. ICs would be used to:

- Alert property owners of the presence of subsurface materials exceeding PCLs
- Describe the need for protective equipment and training if excavation of subsurface materials exceeding PCLs is required in the TCRA footprint or specific areas south of I-10
- Describe requirements for the management of any excavated soil or sediment exceeding PCLs
- Describe the need to restore the cap or clean cover soil in these areas following any disturbance
- Establish limitations on dredging and anchoring within the footprint of the permanent cap

Affected sediment near the upland sand separation area, which is already isolated from potential receptors by several feet of sediment with $TEQ_{DF,M}$ concentrations below the PCL, would be further isolated by deposition of additional sediment as described in Section 2.6 and Appendix A. Monitoring of sediment conditions in this area would be performed to confirm that deposition of clean sediment was continuing to maintain $TEQ_{DF,M}$ concentrations in surface sediments to below the PCL for hypothetical recreational visitors. Implementation of Alternative 4 would trigger additional compliance requirements beyond those discussed in Section 5.3 due to the removal and replacement of the existing TCRA cap, as well as the implementation of the S/S treatment. The removal and replacement of cap material would trigger compliance with CWA Section 404(b)(1) and other ARARs related to surface water quality standards. The S/S may result in a 20 percent increase in the volume of the sediment in the area of treatment because of bulking due to the addition of the stabilization amendment. Application of the S/S to approximately 50,000 to 55,000 cy of sediment is estimated to result in 60,000 to 66,000 cy of amended sediment and this increase in volume could trigger a need to review flood storage impacts in accordance with Federal Emergency Management Agency (FEMA) and Harris County requirements. It is anticipated that Alternative 4, through implementation of the BMPs and the agency coordination actions outlined in Section 3.4, would generally meet the substantive requirements of the ARARs in Table 3-1.

5.4.2 Balancing Criteria

The long-term effectiveness of this remedial alternative is primarily derived from the construction of the permanent cap and treating approximately 53,300 cy of sediment by S/S, combined with the natural recovery processes described previously. Flattening the slopes, where appropriate, as shown on Figures 4-3 and 4-4, would further increase the stability and long-term reliability of the containment as described in Section 5.3. The stabilization of sediment with $TEQ_{DF,M}$ concentrations exceeding the USEPA-designated level of 13,000 ng/kg would provide marginal additional enhancement of the reliability of the containment. This alternative is also effective over the long term because of declines in sediment surface concentrations due to natural recovery (Appendix A) throughout USEPA's Preliminary Site Perimeter. As described in Section 5.2, ICs would protect the integrity of the TCRA cap and the layer of clean surface soil. Monitoring would confirm the continued deposition of clean sediment isolating the affected sediment outside of the footprint of the TCRA cap.

This remedial alternative may reduce the potential mobility of soil/sediment exceeding PCLs using S/S treatment; however, those wastes are already adequately contained within the TCRA cap, and the mobility of these materials is already very low. Approximately 53,300 cy of soil/sediment in the TCRA Site would be treated in situ.

Treatment of the soil/sediment within the TCRA Site would require first removing the existing TCRA cap in the affected area. This would increase the potential risk of a release of the most impacted in situ soil/sediment at the TCRA Site during construction while the cap is removed, and from sediment that may have adhered to the cap materials, which results in an increase in the short-term risk of recontamination beyond the limits of the work area. Shallow mixing augers may be used to implement S/S with minimal exposure of workers to the impacted soil/sediment; however, isolating the soil/sediment with a sheetpile barrier may be a necessary to manage the risk of exposure mentioned above, and to facilitate effective solidification in relatively dry conditions. Successful in situ solidification of wet soil/sediments below surface water has not been documented at full scale, and the presence of free water has been shown to inhibit the chemical reactions necessary to achieve effective S/S (e.g., Manitowac River, Renholds 1998; Kita and Kubo 1983). The use of a sheetpile barrier does little to enhance the short-term effectiveness of this alternative because of documented effectiveness issues (Anchor Environmental 2005; Anchor QEA and Arcadis 2010; and USACE 2008) with engineered barriers, including:

- Incomplete isolation due to gaps in sheetpiles that may occur during installation
- The need to provide openings in the sheetpile to balance water pressures on both sides of the pile
- The potential for river-current-induced scour adjacent to the sheetpile

In addition to these documented issues with sheetpile barriers, the use of sheetpiles increases the risk of recontamination and resuspension of soil/sediments during sheetpile installation and removal (Ecology 1995), and potential cross-contamination associated with driving sheetpiling through impacted materials into non-impacted material. In addition to these environmental risks, the construction duration (15 months) would have higher greenhouse gas, PM, and ozone impacts associated with construction emissions from equipment (Table 4-2) as compared to the previous alternatives. From a worker safety perspective, there is also a moderate risk of accidental injury (Table 4-3) to workers during construction. The remedy, like Alternatives 1 through 3, would achieve protection in the TCRA Site and the area south of I-10 immediately upon implementation; however, protection would not be greater than Alternatives 2 and 3 because the mobility of dioxins/furans is already very low, and the material that would be stabilized is already currently immobilized by the TCRA cap. As with the previous alternatives, additional clean sediment would continue to be deposited within the area of the USEPA's Preliminary Site Perimeter through ongoing natural recovery processes, $TEQ_{DF,M}$ concentrations in the surface sediments would continue to decline, and the buried sediment near the upland sand separation area with $TEQ_{DF,M}$ concentrations exceeding the PCL would be further isolated from potential receptors.

The implementation of this remedial alternative, particularly the treatment of soil/sediment after removal of the TCRA cap, would be significantly more challenging than implementation of Alternative 3. Stabilization of soil/sediment in the floodplain and subtidal areas will require precautions, such as the use of a sheetpile barrier wall to minimize potential releases of materials once the TCRA cap is removed. Even with those precautions, because of the disturbance of sediments caused by removing the TCRA cap, and the additional handling of previously undisturbed sediments during the S/S process, the release of some of these impacted materials into the river or onto the surface of the undisturbed parts of the TCRA cap may be unavoidable, particularly if a storm or high water levels were to occur during construction. The results from chemical fate model simulations of Alternative 4 presented in Appendix A, indicate that short-term increases in surface water concentrations could occur, with such increases being significant at localized scales during the construction. In addition, stabilization in areas that are normally below surface water increases the difficulty in successful implementation of this alternative. Replacement of the TCRA cap following S/S would be implementable with challenges as noted in Section 5.3. Monitoring would involve collecting and analyzing sediment samples and evaluating the data, which are routine procedures for qualified environmental consultants and laboratories. Establishing ICs is routinely done, so there are not anticipated to be administrative implementability issues associated with this remedial alternative. As with Alternative 3, technical implementability issues include obtaining access to the project work area, limited availability of off-site locations for staging, material management, and barge access, and the fact that low clearance under the I-10 Bridge limits the size of marine-based equipment that can access the project work area from the water.

The estimated present worth cost associated with this remedial alternative is $11.2 million (Appendix C). The capital costs for this remedial alternative are primarily associated with the soil/sediment treatment and construction of the permanent cap. The costs of preparing sampling plans, deed restrictions and notices, and a soil management plan are the same as those for remedial Alternative 2. The long-term costs are for monitoring the condition of the permanent cap, collecting and analyzing environmental samples, evaluating the data, preparing reports to document the MNR, and monitoring and maintenance of the TCRA cap. The estimated cost of this alternative assumes 20 TCRA cap monitoring events, five natural recovery monitoring events, and three TCRA cap maintenance events, and also assumes available access to the TCRA Site by water from a location along the river and by land through the TxDOT ROW. The actual number of monitoring events is subject to approval by USEPA.

5.5 Alternative 5– Partial Removal

5.5.1 Threshold Criteria

This remedial alternative achieves the RAOs through a combination of soil/sediment removal, existing engineering controls, ICs, and MNR. Soil and sediment in the TCRA Site with $TEQ_{DF,M}$ concentrations greater than the USEPA-identified limit of 13,000 ng/kg $TEQ_{DF,M}$ would be removed, dewatered, and transported off-site for disposal. A permanent cap meeting the requirements of Alternative 3 would be re-constructed following removal of the soil/sediment. ICs would be used to:

- Alert property owners of the presence of remaining subsurface material exceeding PCLs
- Describe the need for protective equipment and training to limit exposure to contaminants if future additional excavation is required in the TCRA footprint or specific areas south of I-10
- Describe requirements for the management of any excavated soil or sediment
- Describe the need to restore the cap or clean cover soil in these areas following any disturbance
- Establish limitations on dredging and anchoring within the footprint of the permanent cap

Affected sediment near the upland sand separation area, which is already isolated from potential receptors by several feet of sediment with $TEQ_{DF,M}$ concentrations below the PCL, would be further isolated by deposition of additional sediment as described in Section 2.6 and Appendix A. Monitoring of sediment conditions in this area would be performed to confirm that deposition of clean sediment was continuing to maintain $TEQ_{DF,M}$ concentrations in surface sediments below the PCL for protection of hypothetical recreational visitors.

Implementation of Alternative 5 would include the removal of portions of the existing TCRA cap, removal of underlying soil/sediment, and transportation of sediment to an upland disposal facility. The removal of the TCRA cap and placement of rock for permanent cap construction would trigger compliance with CWA Section 404(b)(1) and along with the dredging action would trigger other ARARs related to surface water quality standards.

Should Alternative 5 be identified as the remedy, additional evaluations would be conducted to determine the potential habitat impacts related to the construction of the permanent cap, dredging, and placement of clean residual cover material. The removal of sediment would require the construction of a transload facility near the work area to offload barges, manage waste, stockpile, and dewater sediment, and load these materials onto trucks or rail cars for off-site disposal. The construction and operation of the transload facility will require substantial compliance with relevant requirements. Although land for the transload facility may not be available within the USEPA's Preliminary Site Perimeter, the NCP (40 CFR 300.430(e)) defines on-site for this purpose as "the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action." Alternative 5 would be expected, through implementation of the BMPs and the agency coordination actions outlined in Section 3.4, to generally meet the substantive requirements of the ARARs in Table 3-1.

5.5.2 Balancing Criteria

The long-term effectiveness of this remedial alternative is primarily derived from the construction of the permanent cap and removing approximately 53,300 cy of sediment from the TCRA Site, combined with natural recovery as described previously. Long-term effectiveness is reduced by the fact that this alternative will generate dredge residuals from the resuspension of dioxin-impacted sediments that have been documented on other projects as discussed in the RAM (Anchor QEA 2012b). These dredge residuals would likely have concentrations that are similar to the concentrations of the materials that are dredged (e.g., greater than 13,000 ng/kg $TEQ_{DF,M}$). Flattening the slopes, where appropriate, as shown on Figures 4-3 and 4-4, would further increase the stability and long-term reliability of the containment as described in Section 5.3. The removal of sediment with $TEQ_{DF,M}$ concentrations exceeding 13,000 ng/kg may marginally enhance the reliability of the containment, however, it may degrade the reliability of the existing containment at the interface between the backfill and the existing cap where scour could undermine the edges of the permanent cap. This alternative is also effective over the long term because of declines in sediment surface concentrations due to natural recovery (Appendix A) throughout USEPA's Preliminary Site Perimeter. As described in Section 5.2, ICs would protect the integrity of the remaining TCRA cap and the layer of clean surface soil.

Monitoring would confirm the continued deposition of clean sediment isolating the affected sediment outside of the footprint of the TCRA cap.

This remedial alternative would reduce the volume of sediment exceeding PCLs within the USEPA's Preliminary Site Perimeter. Approximately 53,300 cy of sediment in the TCRA Site would be removed for disposal; however, these sediments are already effectively contained by the TCRA cap and dioxins and furans within the USEPA's Preliminary Site Perimeter have been shown to have very low solubility and are highly immobile. Sediment dewatering by amendment prior to transporting for disposal may reduce the potential mobility of COCs during transportation and at the disposal facility.

Removal of sediment from the TCRA Site would require first removing the existing TCRA cap in the affected area. This would increase the potential risk of a release of soil/sediment with concentrations exceeding 13,000 $TEQ_{DF,M}$ during construction. Releases would be expected during dredging with potential sediments impacted by releases of dioxins and furans (both dredge residuals, as well as dissolved phase), potentially settling onto areas of the TCRA cap and other areas within the USEPA's Preliminary Site Perimeter, and potentially causing temporary increases in surface water and tissue concentrations for various COCs. For example, results from chemical fate model simulations presented in Appendix A, indicate that short-term increases in surface water concentrations could occur, with such increases being significant at localized scales during the construction (e.g., an order of magnitude). To mitigate the potential impacts from resuspended sediments, the work area would need to be isolated with a turbidity barrier/silt curtain or other engineered barrier, although there are documented limitations in the effectiveness of these types of engineered controls (Anchor Environmental 2005; Anchor QEA and Arcadis 2010; and USACE 2008). Project experience at other sediment remediation sites demonstrates that even with the use of engineered controls, sediment resuspension beyond the work area would occur. Sheetpile or some other barrier would be required to dewater the project work area, if excavation is performed using land-based earth-moving equipment rather than a dredge. Even with those precautions, it would be very difficult to avoid releasing some of these materials exceeding PCLs into the river or onto the surface of the undisturbed parts of the TCRA cap if a storm or high water levels occur during construction.

Additional environmental risks include the possibility of spills during transportation to the disposal facility, potential emissions associated with incineration, and possible releases from the off-site landfill itself. In addition to these environmental risks, as compared to the previous four alternatives, the construction duration (12 months, Table 4-1) for this alternative would have higher greenhouse gas and PM emission impacts and ozone generation associated with construction emissions from equipment operating within the project work area, as well as from equipment required for transportation and disposal of excavated sediments (Table 4-2). From a worker safety perspective, there is a low to moderate risk of accidental injury to workers during construction (Table 4-3). The remedy, like Alternatives 1 through 4, would achieve full protection in the TCRA Site and the area south of I-10 immediately upon completion of construction, although with no greater degree of protection than the other alternatives. As with the other alternatives, additional clean sediment continues to be deposited throughout the USEPA's Preliminary Site Perimeter, $TEQ_{DF,M}$ concentrations in surface sediments would continue to decline and the buried sediment near the upland sand separation area with $TEQ_{DF,M}$ concentrations exceeding the PCL would be further isolated from potential receptors.

There are several significant implementability concerns associated with this remedial alternative. As discussed above, removal of sediment in the floodplain would require the use of extensive engineering controls to minimize any releases of highly contaminated sediment during construction and some releases to the surrounding environment could occur (Anchor Environmental 2005; Anchor QEA and Arcadis 2010; and USACE 2008). The modeling of Alternative 5 presented in Appendix A shows that these releases could impact surface water and surface sediment concentrations on both short and long timescales. Further, space is very limited to accommodate contractor access, staging, stockpiling materials, and managing excavated sediment for transportation to an off-site disposal site. Replacement of the cap following sediment removal and backfilling would be implementable with challenges as noted in Section 5.3. Monitoring would involve collecting and analyzing sediment samples and evaluating the data, which are routine procedures for qualified environmental consultants and laboratories. Establishing ICs is routinely done, so there are not anticipated to be administrative implementability issues associated with this remedial alternative either.

The estimated present worth cost associated with this remedial alternative ranges from $24 million to over $118 million (Appendix C) depending on whether the material is landfilled or incinerated. The capital costs for this remedial alternative are primarily associated with the sediment removal and disposal and construction of the permanent cap. The costs of preparing sampling plans, deed restrictions and notices, and a soil management plan are the same as those for remedial Alternative 2. The long-term costs are for monitoring the condition of the permanent cap, collecting and analyzing environmental samples, evaluating the data, preparing reports to document the MNR, and monitoring and maintenance of the TCRA cap. The estimated cost of this alternative assumes 20 TCRA cap monitoring events, five natural recovery monitoring events, and three TCRA cap maintenance events, and also assumes available access to the TCRA Site by water from a location along the river and by land through the TxDOT ROW. The actual number of monitoring events will be subject to approval by USEPA.

5.6 Alternative 6 – Full Removal of Materials Exceeding the Protective Concentration Level

5.6.1 Threshold Criteria

This remedial alternative would provide achieve the RAOs through a combination of soil/sediment removal, ICs, and MNR. Soil/sediment in the TCRA Site and near the upland sand separation area with $TEQ_{DF,M}$ concentrations exceeding the hypothetical recreational visitor PCL (220 ng/kg) would be removed, dewatered, and transported to a permitted incinerator or landfill for disposal. This PCL is very conservative for the area within the TCRA footprint considering the anticipated future industrial or commercial use of the property but could allow for potentially less restricted future use. ICs would be used to:

- Alert property owners of the presence of remaining subsurface material exceeding PCLs
- Describe the need for protective equipment and training to limit exposure to contaminants if future excavation is required in specific areas south of I-10
- Describe requirements for the management of any excavated soil or sediment
- Describe the need to restore the cap or clean cover soil in these areas following any disturbance.

Implementation of Alternative 6 would generally trigger the same compliance requirements as Alternative 5. Were Alternative 6 to be identified as the preferred alternative, additional evaluations would need to be conducted to determine the potential habitat impacts related to impacts of dredging and placement of clean residual layer management materials to document compliance with CWA Section 404(b)(1) and other natural-resource based ARARs.

5.6.2 Balancing Criteria

The long-term effectiveness of this remedial alternative is primarily derived from the removal of soil and sediment, although soils and sediments are already effectively contained by the existing TCRA cap. Approximately 208,300 cy of soil and sediment would be removed from the TCRA Site and from the area near the upland sand separation area. The anticipated limits of the excavation are shown on Figures 4-5 and 4-6. The dredging activity would reduce the volume of soil/sediment with concentrations above 220 mg/kg $TEQ_{DF,M}$; however, it is expected that a residual layer of contaminated materials would remain at the bottom of the excavated surfaces. The concentration of those residual materials would be similar to the removed materials and would likely require a clean sediment residuals cover across the dredge footprint.

A long-term fate and transport model simulation was conducted for Alternative 6 to evaluate the comparative long-term effectiveness of this alternative and quantify potential water and sediment quality impacts during dredging (see Section 4.2 of Appendix A). Results from this simulation indicate that surface sediment concentrations averaged over the USEPA's Preliminary Site Perimeter increase by nearly a factor of three for the 21-year duration of the simulation period compared to natural recovery scenarios; these predicted increases are a result of releases of sediment and dissolved phase dioxins and furans during dredging and sediment residuals within the TCRA Site, even with the use of a post-dredge residuals management cover. However, ongoing deposition would also act to reduce concentrations impacted by dredge residuals and releases within the USEPA's Preliminary Site Perimeter over the long term, but not to the same levels as predicted for the other alternatives. Under this alternative, the material exceeding PCLs south of I-10 would be considered to be effectively isolated from potential receptors, and ICs would address unacceptable risks to excavation workers.

This remedial alternative would remove sediment exceeding PCLs from within the USEPA's Preliminary Site Perimeter. Approximately 208,300 cy of sediment would be removed from within the USEPA's Preliminary Site Perimeter for disposal; however, these sediments are already effectively contained by the TCRA cap and dioxins and furans within the USEPA's Preliminary Site Perimeter have been shown to have very low solubility and are highly immobile. Sediment dewatering by amendment prior to transporting the sediment to a landfill or incinerator for disposal would reduce the potential mobility of COCs during transportation and at the disposal facility. Water generated from sediment dewatering would need to be treated on-site for discharge, or collected and transported off-site for disposal.

Removal of sediment from the TCRA Site would require first removing the existing TCRA cap in the affected area. This would increase the potential risk of a release of sediment with the highest concentrations within the USEPA's Preliminary Site Perimeter during construction. In addition, short-term water quality impacts would occur due to dredging operation releases (Appendix A). For example, the model simulation of Alternative 6 indicates that for an assumed dredge release rate of 3 percent[4] (based on experience from other dredging projects; see Table 5-2), average surface water 2,3,7,8-TCDD concentrations within the USEPA's Preliminary Site Perimeter would be predicted to increase by more than an order of magnitude during dredging. These releases would also be expected to increase tissue concentrations in the early years following remedy implementation and also result in slight increases in surface sediment concentration in surrounding areas (Appendix A). To minimize the potential for release of impacted sediment during construction, the work area would need to be protected with a turbidity barrier/silt curtain. As mentioned previously, however, there are documented limitations on the effectiveness of these types of controls. In addition to these environmental risks, the construction duration (15 months) would have high greenhouse gas, PM, and ozone impacts associated with construction emissions from equipment operating in the work areas (Table 4-2), as well as from equipment required for

[4] As discussed in Appendix A, this percentage applies to the contaminant mass within the dredge prism, and is simulated as a dissolved phase release in the model.

off-site transportation and disposal of excavated sediments. From a worker safety perspective, there is a moderate to high risk of accidental injury to workers during construction (Table 4-3). The remedy would be intended to achieve full protection upon completion of construction; however, it is likely there would be potentially significant releases of dioxins and furans to the surrounding environment during implementation that would be unavoidable and would affect the water column, increase sediment concentrations beyond the work area, and increase tissue concentrations of COCs.

There are several significant implementability concerns associated with this remedial alternative. As discussed above, removal of sediment in the floodplain would require the use of extensive engineering controls to minimize the release of highly contaminated sediment during construction; nevertheless some loss is expected based on documented case histories and published guidance (e.g., USACE 2008) even with the use of those controls. It would be extremely difficult to avoid releasing contaminated materials into the river, particularly if a storm or high water levels occur during construction. Further, space is very limited to accommodate access, staging and stockpiling materials and excavated sediment for transportation to an off-site disposal site. This logistical concern would be much more significant for this remedial alternative than for the partial removal (Section 5.5) because of the longer duration of the project, the greater extent of the removal area, which would leave less upland space for managing materials, as well as the greater volume of material removed which would have significantly greater community impacts (traffic, noise, air emissions, etc.) during implementation. Given the scope and scale of this alternative, it is likely that a relatively large river-side property near the work area would need to be leased for the duration of the work to accommodate staging, material processing, stockpiling, and transloading of materials, which adds additional complexity to this alternative. Finally, the volume of material removed could have a significant impact on the capacity of available landfills, and the availably of incineration facilities to handle this volume is uncertain; thus the acceptance of this amount of material for disposal is uncertain. Establishing ICs is routinely done, so there are not any anticipated administrative implementability issues associated with this remedial alternative.

The estimated present worth cost associated with this remedial alternative is over $100 million to over $600 million if incineration were to be required by the disposal facility. The capital costs for this remedial alternative are primarily associated with the sediment removal and disposal. The costs of preparing sampling plans, deed restrictions and notices, and a soil management plan are the same as those for remedial Alternative 2. The estimated cost of this alternative assumes five natural recovery monitoring events, although the actual number of such events would be subject to approval by USEPA.

6 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

This section compares the alternatives relative to each of the FS evaluation criteria listed under the NCP. Table 5-1 summarizes the criteria for each alternative and provides the basis for the comparative evaluation discussion in this section.

6.1 Threshold Criteria

All of the remedial alternatives evaluated in this FS satisfy the threshold criteria of protecting human health and the environment and addressing ARARs. As noted in the RAM, the surface weighted average $TEQ_{DF,M}$ concentration in surface sediments was reduced by more than 80 percent by the implementation of the TCRA. Based on the fate and transport modeling, this reduction in sediment concentration translates to improvements in water quality throughout the USEPA's Preliminary Site Perimeter (see Table 3-2 in Appendix A), even though there are ongoing inputs of dioxins and furans from external sources, as discussed previously. The current (post-TCRA) condition within the USEPA's Preliminary Site Perimeter is such that there is little potential for exposure to $TEQ_{DF,M}$ concentrations exceeding the applicable soil and sediment PCLs.

- In the area south of I-10, isolated pockets of subsurface soil with $TEQ_{DF,M}$ concentrations exceeding the hypothetical future construction worker PCL are isolated from the surface by several feet of clean soil. Potential exposure to soil exceeding the PCL in this area is limited to circumstances involving excavation into the affected depth zone or contact with excavated soil left at the surface. The hypothetical future construction worker PCL is based on exposure to soil from zero to 10 feet below the surface.
- In the footprint of the TCRA cap, sediment with $TEQ_{DF,M}$ concentrations exceeding the hypothetical future commercial worker PCL is isolated from the surface by the cap. In part of the area, the affected sediment has already been treated with S/S, which further limits exposure potential. Potential exposure to sediment exceeding the PCL in this area is limited to a scenario in which the TCRA cap is compromised by excavation or a catastrophic erosion event, both of which are unlikely due to security fencing around the TCRA Site, the robust nature of the TCRA cap design and ongoing OMM of the cap.
- For the rest of the USEPA's Preliminary Site Perimeter, the sediment PCL is for the

hypothetical recreational visitor exposure scenario. The only sediment with $TEQ_{DF,M}$ concentrations exceeding this PCL is at one sampling location (SJNE032) near the upland sand separation area, and this sediment is overlain by 3 feet of sediment with $TEQ_{DF,M}$ concentrations below the PCL. This location is part of a secured industrial facility with limitations on access. Model predictions presented in Appendix A indicate that net erosion depths during extreme flood events will be limited to less than 15 centimeters in this area, and that over the long term, ongoing deposition will result in declines in surface sediment concentrations in this area.

6.2 Long-Term Effectiveness

The long-term effectiveness evaluation of MNR-based remedies (Appendix A) projects that the SWAC $TEQ_{DF,M}$ will decrease by approximately a factor of two in a 10 to 15-year time frame within the USEPA's Preliminary Site Perimeter (Appendix A) due to natural sedimentation processes in the river. Construction of the TCRA reduced SWAC $TEQ_{DF,M}$ within the USEPA's Preliminary Site Perimeter by approximately 80 percent, and natural recovery will continue to reduce SWAC $TEQ_{DF,M}$ because of the ongoing input of sediment with low $TEQ_{DF,M}$ concentrations from upstream sources.

Alternative 1 does not include ICs and MNR is not measured over time, so the long-term effectiveness of this alternative ranks lower than Alternatives 2 and 3. The existing TCRA cap slope armor is not enhanced in Alternative 2 compared to Alternative 3, which could increase the need for future long-term monitoring and maintenance under Alternative 2.

Although material is treated or removed under Alternatives 4, 5, and 6, disturbance of the TCRA cap to facilitate construction, as well as potential releases during construction, will reduce the long-term effectiveness of these alternatives compared to Alternative 3. There will also be a requirement for a residuals management cover or backfill over the excavated areas for Alternatives 5 and 6.

Alternative 6 has comparatively lower long term effectiveness: As demonstrated by the modeling (Appendix A), the modeled long-term $TEQ_{DF,M}$ concentration in sediment under this alternative is expected to be more than double that of the MNR-based remedies due to dredging-related releases and dredging residuals. Similar increases were also predicted for Alternatives 4 and 5, but they were at lower concentrations and on more localized scales.

Figures 6-1a and 6-1b compare model-predicted surface sediment TCDD[5] concentrations at the end of the long-term fate model simulation for all six alternatives; results were averaged over the USEPA's Preliminary Site Perimeter and within the TCRA Site (Figure 6-1a), and by river mile in the vicinity of the TCRA Site (Figure 6-1b). These graphics illustrate the comparatively lower long-term effectiveness of Alternative 4, 5, and 6 relative to Alternatives 1 through 3, due to residuals and releases associated with the excavation/stabilization under these alternatives. The long-term impacts of dredge residuals and releases during construction are also evident in the model-predicted water column concentrations at the end of the long-term simulation (see Figure 6-2, which shows model-predicted annual average water column TCDD concentrations at the end of the long-term model simulation for all six alternatives, averaged over the USEPA's Preliminary Site Perimeter and the TCRA Site). These predictions include several sources of dioxins and furans, including atmospheric deposition, upstream sources, and point sources, such as releases from waste-water treatment plant outfalls, in addition to the dioxin-impacted materials potentially released during dredging and S/S activities.

6.3 Reduction of Toxicity, Mobility, or Volume

Alternatives 1 and 2 do not include additional measures to reduce TMV. However, a portion of the soils in the Western Cell were previously solidified during the TCRA as shown on Figures 4-1, 4-3, 4-5 and 4-7. Thus, these alternatives are comparable in reduction of TMV. Alternative 3 further reduces potential mobility within the TCRA Site by increasing the protection of the armored slopes, and thus ranks more favorably than Alternatives 1 and 2. Alternatives 4 and 5 take additional measures through S/S (Alternative 4) or removal (Alternative 5) of approximately 53,300 cy of sediments and soils, and are comparatively better than Alternative 3 for reduction of TMV; however, the potential mobility of the highest concentration materials addressed in these alternatives is increased during remedy

[5] Although the FS focuses on SWAC $TEQ_{DF,M}$ as a metric of sediment quality, the TCDD results from Appendix A provide a reasonable surrogate for $TEQ_{DF,M}$ because TCDD represents the majority of the potential risk in the calculation of $TEQ_{DF,M}$.

implementation, somewhat offsetting this reduction. Alternative 6 has the greatest volume of removal – however, this is offset by significant dredge water column and residual releases and thus this is considered comparable to Alternatives 4 and 5 in terms of reduction of TMV.

6.4 Short-Term Effectiveness

Alternatives 1 and 2 do not entail any construction, and thus have no short-term impacts. Alternative 3 has the shortest duration of the remaining alternatives; does not result in water column, sediment, or tissue impacts (except for minor turbidity during armor rock placement); and has the lowest risk to worker safety, the lowest greenhouse gas and PM emissions, and the least traffic and ozone (smog) impact. Further, Alternative 3 does not disturb the TCRA cap or require handling of sediments. Compared to Alternatives 4, 5, and 6, which have significantly longer durations, Alternative 3 ranks significantly more favorably for short-term effectiveness.

Alternative 4 has a longer construction duration than Alternative 5 and both entail removing portions of the TCRA cap and managing approximately 53,300 cy of sediments. Thus, compared to Alternative 3, there is higher risk to worker safety (8 to 9 times the number of injuries and fatalities, Table 4-3) and higher environmental impacts (8 to 9 times the number of hours of operation and truck trips, Table 4-2) due to releases that would be expected during construction. Alternative 4 is considered similar to Alternative 5 for emissions of ozone precursors, PM (smog-forming) and greenhouse gases; under Alternative 4, construction is limited to work within the USEPA's Preliminary Site Perimeter and does not result in additional emissions during off-site shipment of sediments, but this is counterbalanced by the shorter duration of Alternative 5.

Alternative 6 is the least favorable for short-term effectiveness. The significantly greater number of work hours has attendant higher worker safety risk (20 times the number of injuries and fatalities compared to Alternative 3, Table 4-3) and higher emissions of ozone precursors, PM (smog-forming) and greenhouse gases (20 times the number of equipment operating hours and truck trips compared to Alternative 3, Table 4-2), and the time required for Alternative 6 to achieve protection is also longer. Alternative 6 also has the most significant short-term environmental impact due to water column releases during dredging, and the expected localized increase in tissue concentrations from these releases, as well as generated dredge residuals, that the model predicts may increase the overall SWAC $TEQ_{DF,M}$ immediately following dredging.

Figure 6-3 compares model-predicted annual average water column TCDD concentrations during Year 1 of the model simulation (i.e., water column concentrations that are predicted during construction) for all six alternatives averaged over the USEPA's Preliminary Site Perimeter and within the TCRA Site. As described above, Alternatives 4 through 6 exhibit higher short-term impacts relative to Alternatives 1 through 3 as a result of water column releases that are assumed to occur during removal/stabilization.

6.5 Implementability

Alternatives 1 and 2 do not have any implementability issues because they do not entail construction. Both are more favorable from an implementability standpoint compared to Alternatives 3, 4, 5, and 6. Alternative 3 is a short-duration project that entails proven technology (i.e., the same activities were demonstrated during construction of the TCRA cap) that can be deployed with readily-available materials and local, experienced contractors. Implementability concerns, such as TCRA Site access, limited staging areas, restrictions on equipment size are substantially greater for Alternatives 4, 5, and 6 compared to Alternative 3 because of the much larger scope and scale of these alternatives. Based on these factors, Alternative 3 is less favorable than Alternatives 1 and 2, but more favorable than the remaining alternatives.

Alternative 4 requires the removal of the TCRA cap, which is considered a technical challenge, and requires S/S to be completed for an area of sediments that is typically submerged and would need to be dewatered, which is considered another technical challenge. Engineering controls for Alternative 4 would not be adequate to prevent the release of sediments exceeding PCLs to the surrounding environment; this would be especially true during potential high flow events that could occur during construction. Alternative 4 is considered to be unfavorable for implementability.

Alternatives 5 and 6 also require removal of the TCRA cap, and management of a significant volume of sediment and soil for off-site disposal, including the need to potentially treat some portion of the material through incineration. Similar to Alternative 4, engineering controls would not be adequate to prevent the release of sediments exceeding PCLs to the surrounding environment; this would be especially true during potential high flow events that could occur during construction. Thus, both of these alternatives are considered equally as unfavorable as Alternative 4 for implementability.

6.6 Cost

Table 5-1 includes a summary of estimated costs for each alternative. Appendix C provides the detailed estimates that were developed for this FS. Costs range from lowest to highest in order from Alternative 1 to Alternative 6: Alternative 1 is estimated to cost $1.3 million; Alternative 2 is estimated to cost $1.6 million; Alternatives 3 and 4 differ by a factor of four, with estimated costs of $2.9 and $11.2 million, respectively; Alternative 5 is estimated to range from over $20 to over $100 million depending on whether incineration were to be required as part of disposal; Alternative 6 is estimated to range from over $100 to over $600 million, also depending on whether incineration were to be required.

6.7 Summary of Comparative Benefits and Risks

The comparative benefits of each alternative have been assessed using the modeling described in Appendix A to predict the TCDD sediment and water column concentrations within the USEPA's Preliminary Site Perimeter at the end of construction, and at the end of the long-term simulation period. As is shown in Figures 6-1a, 6-1b, 6-2 and 6-3, there is no demonstration that removal of materials or additional S/S provides any benefit; in contrast, there is less benefit associated with implementing Alternatives 4, 5, or 6 compared to Alternatives 1, 2, and 3.

Conversely, there is significant hazard to implementation associated with Alternatives 4, 5, and 6 as discussed under Short-Term Effectiveness. Risks from environmental impacts during and following construction (water column, sediment, and localized tissue impacts) and worker safety (estimated injury and fatality rates) are significantly (8 to 20 times; Table 4-2 and Table 4-3) higher for Alternatives 4, 5, and 6 than for Alternatives 1, 2, or 3. Finally, Alternatives 4, 5, and 6 are less sustainable alternatives, as assessed, considering potential ozone precursor, PM and greenhouse gas emissions from the construction activity, and will result in more community impact from traffic including on-going daily distractions and the potential for accidents and off-site spills (6 to more than 70 times the number of truck trips; Table 4-2).

Finally, the costs of Alternatives 4, 5, and 6 are significantly higher than for Alternatives 1, 2, and 3 (by factors ranging from 4 times higher to more than 2 orders of magnitude higher). Alternatives 4, 5, and 6 provide no predicted benefit, at significantly increased risk, and significantly increased cost when compared to Alternatives 1, 2, and 3.

6.8 Recommended Remedy

Based on the comparative analysis of remedial alternatives, considerations related to the risk/benefit of the various alternatives presented in this section and as summarized by the considerations described in Table 5-1, the recommended remedy is Alternative 3, which includes a permanent cap, ICs, and MNR. The TCRA cap currently addresses the RAOs pertinent to the TCRA Site by effectively containing the soil/sediment that exceeds the hypothetical future commercial worker PCL for that area. The construction of the permanent cap would reduce the need for long-term maintenance of the existing cap, as demonstrated by the modeling described in Appendix B. The permanent cap would reliably provide permanent containment and isolation of the affected soil/sediment. This remedial alternative could be readily implemented using technologies demonstrated during the construction of the TCRA without increasing risks to workers, the surrounding community, or the environment by exposing the already contained soil/sediment.

By comparison, the treatment and removal alternatives (Alternatives 4, 5, and 6) would require removing the protective cap during construction, increasing the short-term risk of releasing the contaminated sediment and adding significant risk related to releases, generated residuals, water column impacts, and localized temporary increases in tissue COC concentrations during and immediately after S/S or dredging. These alternatives also have substantially greater construction-related impacts, including risks to worker safety, ozone-generating emissions, greenhouse gas emissions, PM emissions, construction traffic, and greater risks to the public from accidents and off-site spills compared to Alternative 3. Alternatives 4, 5, and 6 all have significant implementability challenges associated with treating or removing contaminated sediment in a floodplain. These alternatives, particularly the full removal (Alternative 6), would require the use of a significant amount of land off-site and water access to prepare contaminated sediment for transportation and disposal.

For all of the remedial alternatives, the soil and sediment with $TEQ_{DF,M}$ concentrations exceeding the pertinent PCLs is already isolated by overlying cleaner soil or sediment, or the TCRA cap. ICs will address the RAOs in the area south of I-10 and protect the integrity of the cap in the TCRA Site from human disturbance. Natural recovery will continue to reduce $TEQ_{DF,M}$ concentrations in surface sediment, including in the area near the upland sand separation area where sediment with $TEQ_{DF,M}$ concentrations exceeding the PCL is already isolated from the biologically active zone by several feet of cleaner sediment and additional net sedimentation is predicted to continually occur.

The construction of Alternative 3 could be fully implemented in approximately 2 months from mobilization of a construction contractor. The estimated cost to implement this remedy is $2.9 million.

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TABLES

Table 3-1
Applicable or Relevant and Appropriate Requirements Summary

Potential ARARs[1]	Citation	Summary	Comment
Federal			
Clean Water Act (CWA): Criteria and standards for imposing technology-based treatment requirements under §§ 309(b) and 402 of the Act	33 U.S.C. §§ 1319 and 1342 (implementing regulations at 40 CFR Part 125 Subpart A)	Both on-site and off-site discharges from CERCLA sites to surface waters are required to meet the substantive CWA (National Pollutant Discharge Elimination System) NPDES requirements (USEPA 1988).	On-site discharges must comply with the substantive technical requirements of the CWA but do not require a permit (USEPA 1988). Off-site discharges would be regulated under the conditions of a NPDES permit (USEPA 1988). Standards of control for direct discharges must meet technology-based requirements. Best conventional pollution control technology (BCT) is applicable to conventional pollutants. Best available technology economically achievable (BAT) applies to toxic and non-conventional pollutants. For CERCLA sites, BCT/BAT requirements are determined on a case-by-case basis using best professional judgment. This is likely to be a potential requirement only if treated water or excess dredge water is discharged during implementation.
CWA Sections 303 and 304: Federal Water Quality Criteria	33 U.S.C. §§1313 and 1314 (Most recent 304(a) list as updated to issuance of ROD)	Under §303 (33 U.S.C. §1313), individual States have established water quality standards to protect existing and attainable uses (USEPA 1988). CWA §301(b)(1)(C) requires that pollutants contained in direct discharges be controlled beyond BCT/BAT equivalents (USEPA 1988). CERCLA §121(d)(2)(B)(i) establishes conditions under which water quality criteria, which were developed by USEPA as guidance for States to establish location-specific water quality standards, are to be considered relevant and appropriate. Two kinds of water quality criteria have been developed under CWA §304 (33 U.S.C. §1314): one for protection of human health, and another for protection of aquatic life. These requirements include establishment of total maximum daily loads (TMDL).	The FS considers the ability of remedial alternatives to satisfy established water quality criteria. Best management practices (BMPs) would be established for remedial actions and applied during construction. Water quality would also be monitored during construction and additional BMPs may be implemented if necessary to protect water quality. Where water quality State standards contain numerical criteria for toxic pollutants, appropriate numerical discharge limitations may be derived for the discharge and considered (USEPA 1988). Where State standards are narrative, either the whole-effluent or chemical-specific approach may generally be used as a standard of care (USEPA 1988).
CWA Section 307(b): Pretreatment standards	33 U.S.C. §1317(b)	CERCLA §121(e) states that no Federal, State, or Local permit for direct discharges is required for the portion of any removal or remedial action conducted entirely on-site (the aerial extent of contamination and all suitable areas in close proximity to the contamination necessary for implementation of the response action) (USEPA 1988).	If off-site discharges from a CERCLA response activity were to enter receiving waters directly or indirectly, through treatment at a Publicly Owned Treatment Works (POTWs), they must comply with applicable Federal, State, and Local substantive requirements and formal administrative permitting requirements (USEPA 1988). This requirement may be triggered by disposal methods for waste. Based on the current set of proposed alternatives, none of the alternatives involve discharge to a POTW, and therefore, this regulation is not likely to be applicable.
CWA Section 401: Water Quality Certification	33 U.S.C. §1341	Requires applicants for Federal permits for projects that involve a discharge into navigable waters of the U.S. to obtain certification from State or regional regulatory agencies that the proposed discharge will comply with CWA Sections 301, 302, 303, 306, and 307.	Proposed activities that are on-site would not require a Federal permit. Therefore, certification is not legally required for on-site actions. Certification would be required for off-site actions. For on-site or off-site actions, certification should occur as part of the State identification of substantive State ARARs (USEPA 1988). Compliance with water quality criteria is discussed under CWA Sections 303 and 304.

[1] ARARs are applicable or relevant and appropriate requirements of Federal or State environmental laws and State facility siting laws. CERCLA section 121(d) requires that remedial actions generally comply with ARARs. The USEPA has stated a policy of attaining ARARs to the greatest extent practicable on remedial or removal actions (USEPA 1988). USEPA also stated that certain nonpromulgated Federal and State advisories or guidelines would be considered in selecting remedial or removal actions; these guidelines are referred to as TBCs, or "to be considered."

Table 3-1
Applicable or Relevant and Appropriate Requirements Summary

Potential ARARs[1]	Citation	Summary	Comment
CWA Section 404 and 404(b)(1): Dredge and Fill	33 U.S.C. §1344 (b)(1) (implementing regulations at 33 CFR 320 and 330; 40 CFR 230)	Discharges of dredged and fill material into waters of the U.S. must comply with the CWA §404 (33 U.S.C. 1344) guidelines and demonstrate the public interest is served (USEPA 1988).	The San Jacinto site is a water of the U.S. (USEPA 2007). Dredge and fill permits are applicable to dredging, in-water disposal, capping, construction of berms or levees, stream channelization, excavation and/or dewatering within waters of the U.S. (USEPA 1988). Permits are not required, however, for on-site CERCLA actions. Under the 404(b)(1) guidelines, efforts should be made to avoid, minimize, and mitigate adverse effects on the waters of the U.S. and, where possible, select a practicable (engineering feasible) alternative with the least adverse effects. The substantive requirements of Section 404 will be considered in the development and evaluation of remedial alternatives to minimize adverse impacts to waters of the U.S.
Safe Drinking Water Act	42 U.S.C. §300f (implementing regulations at 40 CFR Part 141, et seq.)	The Safe Drinking Water Act is applicable to public drinking water sources at the point of consumption (“at the tap”). Maximum contaminant levels (MCLs) have been established for certain constituents to protect human health and to preserve the aesthetic quality of public water supplies.	Safe Drinking Water Act standards are applicable to public drinking water sources. The San Jacinto River is not a public water supply and does not recharge an aquifer used to supply drinking water. Therefore, the Safe Drinking Water Act is not applicable. The MCL for 2,3,7,8-tetrachlorodibenzodioxin may be considered for protecting water quality.
Federal Drinking Water Regulations (Primary and Secondary Drinking Water Standards)[2]	40 CFR 141 and Part 143	USEPA has established two sets of drinking water standards: one for protection of human health (primary) and one to protect aesthetic values of drinking water (secondary) (USEPA 1988). MCLs are applicable to public drinking water sources at the point of consumption.	Safe Drinking Water Act standards are applicable to public drinking water sources. The San Jacinto River is not a public water supply and does not recharge an aquifer used to supply drinking water. Therefore, the Safe Drinking Water Act is not applicable. The MCL for 2,3,7,8-tetrachlorodibenzodioxin may be considered for protecting water quality.
Resource Conservation And Recovery Act (RCRA): Hazardous Waste Management	42 U.S.C. §§6921 et seq. (implementing regulations at 40 CFR Parts 260 – 268)	RCRA is intended to protect human health and the environment from the hazards posed by waste management (both hazardous and nonhazardous). RCRA also contains provisions to encourage waste reduction. RCRA Subtitle C and its implementing regulations contain the Federal requirements for the management of hazardous wastes.	This requirement would apply to certain activities if the affected sediments contain RCRA listed hazardous waste or exhibit a hazardous waste characteristic. RCRA requirements are applicable only if waste is managed (treated, stored, or disposed of) after effective date of RCRA requirement under consideration or if CERCLA activity constitutes treatment, storage, or disposal as defined by RCRA. The sludge and sediment at the site are not listed hazardous waste, do not contain listed hazardous waste, and do not meet any of the characteristics of hazardous waste. Therefore, the RCRA rules for hazardous waste are neither applicable nor relevant and appropriate.
RCRA: General Requirements for Solid Waste Management	42 U.S.C. §§6941 et seq. (implementing regulations at 40 CFR 258)	Requirements for construction for municipal solid waste landfills that receive RCRA Subtitle D wastes, including industrial solid waste. Requirements for run-on/run-off control systems, groundwater monitoring systems, surface water requirements, etc.	This requirement would be relevant if a landfill was constructed for the disposal of non-hazardous solid waste. There are no specific Federal requirements for non-hazardous waste management; State regulations provide specific applicable requirements for siting, design, permitting, and operation of landfills.
Clean Air Act (CAA)	42 U.S.C. §§7401 et seq.	Would apply if dredging and/or excavation activities generate air emissions sufficient to require a permit, greater than 10 tons of any pollutant per year under the CAA operational permit (USEPA 2009).	None of the remedial alternatives is expected to trigger an operational permit.
Rivers And Harbors Act of 1899: Obstruction of navigable waters (generally, wharves; piers, etc.); excavation and filling-in	33 U.S.C. §401	Controls the alteration of navigable waters (i.e., waters subject to ebb and flow of the tide shoreward to the mean high water mark). Activities controlled include construction of structures such as piers, berms, and installation of pilings as well as excavation and fill. Section 10 may be applicable for any action that may obstruct or alter a navigable waterway.	No permit is required for on-site activities. However, substantive requirements might limit in-water construction activities.

[2] Underground injection is not anticipated as a part of the potential remedial action. Furthermore, the site is not located in a sole-source aquifer (USEPA 2008). It is also assumed that no wellhead protection area is located near the study area.

Table 3-1
Applicable or Relevant and Appropriate Requirements Summary

Potential ARARs[1]	Citation	Summary	Comment
Endangered Species Act	16 U.S.C. §§ 1531 et seq.	Federal agencies must ensure that actions they authorize, fund, or carry out are not likely to adversely modify or destroy critical habitat of endangered or threatened species. Actions authorized, funded, or carried out by Federal agencies may not jeopardize the continued existence of endangered or threatened species as well as adversely modify or destroy their critical habitats.	Based on a 2010 evaluation, as well as a desktop review of site photos and USFWS and NMFS species and habitat maps, no Federally listed threatened or endangered (T&E) species or their critical habitat are present on the site or utilize areas in the vicinity of the site. Therefore,this requirement is not relevant to the evaluation of remedial alternatives. NMFS includes endangered sea turtles in Trust resources impacted by contaminated surface water and sediments that may have been transported from the site. USEPA will consult with the resource agencies to gain concurrence on the determination that the roposed remedial alternative will have no effect on listed species.
Fish and Wildlife Coordination Act	16 U.S.C. §§661 et seq., 16 U.S.C. §742a, 16 U.S.C. § 2901	Requires adequate provision for protection of fish and wildlife resources. This title has been expanded to include requests for consultation with USFWS for water resources development projects (Mueller 1980). Any modifications to rivers and channels require consultation with the USFWS, Department of Interior, and state wildlife resources agency[3]. Project-related losses (including discharge of pollutants to water bodies) may require mitigation or compensation.	Applicable to any action that controls or modifies a body of water.
Bald and Golden Eagle Protection Act	16 U.S.C. §668a-d	Makes it unlawful to take, import, export, possess, buy, sell, purchase, or barter any bald or golden eagle, nest, or egg. "Take" is defined as pursuing, hunting, shooting, poisoning, wounding, killing, capturing, trapping and collecting, molesting, or disturbing.	This requirement is potentially relevant to CERCLA activities. No readily available information suggests bald or golden eagles frequent the project area; however, a qualified biologist would perform a site visit prior to a potential remedial action to confirm that bald and golden eagles do not frequent the project area.
Migratory Bird Treaty Act	16 U.S.C. §§703-712 (implementing regulations at 50 CFR §10.12)	Makes it unlawful to take, import, export, possess, buy, sell, purchase, or barter any migratory bird. "Take" is defined as pursuing, hunting, shooting, poisoning, wounding, killing, capturing, and trapping and collecting.	This requirement is potentially relevant to CERCLA activities. No readily available information suggests migratory birds frequent the project area, and aerial photography of the site suggests no suitable nesting or stopover habitat is present; however, a qualified biologist would perform a site visit prior to a potential remedial action to confirm that migratory birds do not frequent the project area.
Coastal Zone Management Act	16 USC §§1451 et seq. (implementing regulations at 15 CFR 930)	Federal activities must be consistent with, to the maximum extent practicable, State coastal zone management programs. Federal agencies must supply the State with a consistency determination (USEPA 1989).	The San Jacinto River lies within the Coastal Zone Boundary according to the Texas Coastal Management Plan (TCMP) prepared by the General Land Office (GLO). The FS considers whether the remedial alternatives would affect (adversely or not) the coastal zone, and the lead agency is required to determine whether the activity will be consistent with the State's CZMP (USEPA 1989). More information regarding the State requirements is provided under Texas Coastal Coordination Council (TCCC) Policies for Development in Critical Areas.
FEMA (Federal Emergency Management Agency), Department of Homeland Security (Operating Regulations)	42 U.S.C. 4001 et seq. (implementing regulations at 44 CFR Chapter 1)	Prohibits alterations to river or floodplains that may increase potential for flooding.	This requirement is relevant to CERCLA activities in floodplains and in the river because the project area is within a designated flood zone. The FS includes a brief review of the potential impacts of remedial alternatives on the floodplain, and there will be a full evaluation of the selected alternative as part of the remedial design process.
National Flood Insurance Program (NFIP) Regulations	42 U.S.C. subchapter III, §§4101 et seq.	Provides Federal flood insurance to local authorities and requires that the local authorities not allow fill in the river that would cause an increase in water levels associated with floods.	The FS includes a brief review of the potential impacts of remedial alternatives on the floodplain, and there will be a full evaluation of the selected alternative as part of the remedial design process.

[3] Texas Parks and Wildlife Department.

Table 3-1
Applicable or Relevant and Appropriate Requirements Summary

Potential ARARs[1]	Citation	Summary	Comment
Title 40: Protection of the Environment - Statement of Procedures on Floodplain Management and Wetlands Protection	40 CFR Part 6 App. A; Executive Orders (EO) 11988 and 11990	Requires Federal agencies to conduct their activities to avoid, if possible, adverse impacts associated with the destruction or modification of wetlands and occupation or modification of floodplains. Executive Orders 11988 and 11990 require Federal projects to avoid adverse effects and minimize potential harm to wetlands and within flood plains. The EO 11990 requires Federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative (USEPA 1994).	This requirement is potentially relevant to disposal or treatment activities in the upland as well as any in-water facilities that might displace floodwaters. The waste pits are located within the floodway and Zone AE, or the 1% probability floodplain. The FS includes a brief review of the potential impacts of remedial alternatives on the floodplain, and there will be a full evaluation of the selected alternative as part of the remedial design process. Effects on the base flood, typically the 100-year or 1% probability flood, should be minimized to the maximum extent practicable (Code of Federal Regulations 1985 as amended). The agency also adopted a requirement that the substantive requirements of the Protection of Wetlands Executive Order must be met (USEPA 1994). Unavoidable impacts to wetlands must be mitigated (USEPA 1994)[4].
National Historic Preservation Act	16 U.S.C. §§ 470 et seq. (implementing regulations at 36 CFR 800)	Section 106 of this statute requires Federal agencies to consider effects of their undertakings on historic properties. Historic properties may include any district, site, building, structure, or object included in or eligible for the National Register of Historic Places (NRHP), including artifacts, records, and material remains related to such a property.	According to the San Jacinto River Waste Pits Remedial Investigation/Feasibility Study (RI/FS) cultural resources assessment, "no NRHP-eligible properties are documented in the area of concern. Because of the extensive disturbance to the site and minimal ground disturbance that will likely occur for the project, it is not likely that NRHP-eligible historic properties will be affected by RI/FS or eventual site remediation activities" (Anchor QEA 2009).
Noise Control Act	42 U.S.C. §§ 4901 et seq. (implementing regulations at 40 CFR Subchapter G §201 et seq.	Noise Control Act remains in effect but unfunded (USEPA 2010).	Noise is regulated at the State level. See Texas Penal Code under State ARARs.
Hazardous Materials Transportation Act	49 U.S.C. §§1801 et seq. (implementing regulations at 49 CFR. Subchapter C)	Establishes standards for packaging, documenting, and transporting hazardous materials.	This requirement would apply to remedial alternatives that involve transporting hazardous materials off-site for treatment or disposal.

[4] Each agency is expected to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands when implementing actions such as CERCLA sites (President of the United States 1977). If §404 of the Clean Water Act is considered an ARAR, then the 404(b)(1) guidelines established in a Memorandum of Understanding (MOU) between USEPA and Department of Army should be followed (USEPA 1994). When habitat is severely degraded, a mitigation ratio of 1:1 may be acceptable (USEPA 1994). However, any mitigation would be at the discretion of the agency and the USEPA may elect to orient mitigation towards "minimizing further adverse environmental impacts rather than attempting to recreate the wetlands original value on site or off site" (USEPA 1988).

Table 3-1
Applicable or Relevant and Appropriate Requirements Summary

Potential ARARs	Citation	Summary	Comment
State			
30 Texas Administrative Code (TAC) Part 1: Industrial Solid Waste and Municipal Hazardous Waste General Terms	30 TAC §§335.1 – 335.15	General Terms: Substantive requirements for the transportation of industrial solid and hazardous wastes; requirements for the location, design, construction, operation, and closure of solid waste management facilities.	Guidelines to promote the proper collection, handling, storage, processing, and disposal of industrial solid waste or municipal hazardous waste in a manner consistent with the purposes of Texas Health and Safety Code, Chapter 361. Solid nonhazardous waste provisions are applicable if material is transported to an upland disposal facility.
30 TAC Part 1: Industrial Solid Waste and Municipal Hazardous Waste: Notification	30 TAC Chapter 335 Subchapter P	Requires placement of warning signs in contaminated and hazardous areas if a determination is made by the executive director of the Texas Water Commission a potential hazard to public health and safety exists which will be eliminated or reduced by placing a warning sign on the contaminated property.	Warning signs and fencing were placed around the site as part of the Time Critical Removal Action. The FS includes additional institutional controls for all alternatives, including additional warning signs and fencing.
30 TAC Part 1: Industrial Solid Waste and Municipal Hazardous Waste: Generators	30 TAC Chapter 335, Subchapter C	Standards for hazardous waste generators either disposing of waste on-site or shipping off-site with the exception of conditionally exempt small quantity generators. The definition of hazardous involves State and Federal standards.	The sludge and sediment at the site are not listed hazardous waste, do not contain listed hazardous waste, and do not meet any of the characteristics of hazardous waste. Therefore, the rules for hazardous waste are neither applicable nor relevant and appropriate.
Texas Surface Water Quality Standards	30 TAC §307.4-7, 10	These state regulations provide: • General narrative criteria • Anti-degradation Policy • Numerical criteria for pollutants • Numerical and narrative criteria for water-quality related uses (e.g., human use) • Site specific criteria for San Jacinto basin	Surface water quality standards are potentially relevant to the determination of risks, but should not override any site-specific toxicity values or risks determined through the risk assessment process. It is also relevant to the identification of potential sources and the short-term and long-term effectiveness of removal alternatives.
Texas Water Quality: Pollutant Discharge Elimination System (TPDES)	30 TAC §279.10	These state regulations require stormwater discharge permits for either industrial discharge or construction-related discharge. The State of Texas was authorized by USEPA to administer the NPDES program in Texas on September 14, 1998 (Texas Commission on Environmental Quality 2009).	The proposed remedial alternatives evaluated in the FS do not include off-site remedial action beyond disposal of sediments in upland disposal facilities that would be previously permitted, and therefore no discharge permit for off-site remedial actions would be required.
Texas Water Quality: Water Quality Certification	30 TAC §279.10	These state regulations establish procedures and criteria for applying for, processing, and reviewing state certifications under CWA, §401. It is the purpose of this chapter, consistent with the Texas Water Code and the federal CWA, to maintain the chemical, physical, and biological integrity of the state's waters.	The development and evaluation of remedial alternatives will include consideration of potential water-quality impacts, relevant to the Water Quality Certification in Texas. Although permits are not required for on-site CERCLA actions, water quality certification is relevant as part of identification of substantive state ARARs (USEPA 1988).
Texas Risk Reduction Program	30 TAC §350	Activated upon release of Chemicals of Concern (COC). The Risk Reduction Program uses a tiered approach incorporating risk assessment techniques to help focus investigations, to determine appropriate protective concentration levels for human health, and when necessary, for ecological receptors. Includes protective concentration levels.	Risk assessment was performed as part of the remedial investigation. Sediment and soil contaminated with COCs is isolated from potential receptors by existing soil and sediment or the TCRA cap such that there are no unacceptable risks to human health or the environment. The remedial alternatives would increase the permanence of the existing barriers to exposure, thereby enhancing the risk reduction.
Natural Resources Code, Antiquities Code of Texas	Texas Parks and Wildlife Commission Regulations 191.092-171	Requires that the Texas Historical Commission staff review any action that has the potential to disturb historic and archeological sites on public land. Actions that need review include any construction program that takes place on land owned or controlled by a state agency or a state political subdivision, such as a city or a county. Without local control, this requirement does not apply.	Assessment of historical resources during the TCRA produced no known eligible properties and determined that disturbance of any archaeological or historic resources is unlikely within the TCRA Site. Depending on the magnitude and specific boundaries of ground disturbance determined during the FS for the overall site, this ARAR will need to be re-evaluated relative to CERCLA activities outside of the TCRA boundaries. (Anchor QEA 2009).
Practice and Procedure, Administrative Code of Texas	13 TAC Part 2, Chapter 26	Regulations implementing the Antiquities Code of Texas. Describes criteria for evaluating archaeological sites and permit requirements for archaeological excavation.	This requirement is only applicable if an archaeological site is found; based on evaluations conducted as part of the RI/FS and TCRA processes, it is unlikely that archaeological resources would be found on the Site.

Table 3-1
Applicable or Relevant and Appropriate Requirements Summary

Potential ARARs	Citation	Summary	Comment
State of Texas Threatened and Endangered Species Regulations	31 TAC 65.171 - 65.176	No person may take, possess, propagate, transport, export, sell or offer for sale, or ship any species of fish or wildlife listed as threatened or endangered.	The presence or absence of state T&E species was evaluated in 2010, and concluded that no state T&E species were likely to occur on the Site or in the vicinity.
TCCC Policies for Development in Critical Areas	31 TAC §501.23	Dredging in critical areas is prohibited if activities have adverse effects or degradation on shellfish and/or jeopardize the continued existence of endangered species or results in an adverse effect on a coastal natural resource area (CNRA)[5]; prohibit the location of facilities in coastal natural resource areas unless adverse effects are prevented and /or no practicable alternative. Actions should not be conducted during spawning or nesting seasons or during seasonal migration periods. Specifies compensatory mitigation.	The FS evaluates the potential effects of remedial alternatives on Coastal Natural Resource Area (CNRAs), which includes coastal wetlands (Railroad Commission of Texas n.d.).
Texas Coastal Management Plan Consistency	31 TAC, §506.12	Specifies Federal actions within the CMP boundary that may adversely affect CNRAs; specifically selection of remedial actions.	The San Jacinto River lies within the Coastal Zone Boundary (GLO TCMP). The FS will evaluate whether remedial alternatives may affect (adversely or not) the coastal zone and will provide a technical basis for the lead agency to determine whether the activity will be consistent with the State's CZMP (USEPA 1989).
Texas State Code – obstructions to navigation	Natural Resources Code § 51.302 Prohibition and Penalty	Prohibits construction or maintenance of any structure or facility on land owned by the State without an easement, lease, permit, or other instrument from the State.	The FS evaluates whether the remedial alternatives include construction on state-owned land, and implementation of any alternative occurring on state lands presumes the obtainment of an easement, lease, permit, or other instrument from the State.
Noise Regulations	Texas Penal Code Chapter 42, Section 42.01	The Texas Penal Code regulates any noise that exceeds 85 decibels after the noise is identified as a public nuisance.	Noise abatement may be required if actions are identified as a public nuisance. Due to the isolation of the site, its location adjacent to a freeway with high volumes of traffic during normal working hours, and the industrial nature of the nearest properties, noise from construction activity associated with a potential remedial action is unlikely to constitute a public nuisance. Noise associated with truck traffic to and from the site should be considered for alternatives that involve transportation of materials off-site.
Local			
Harris County Floodplain Management Permit[6]	Regulations of Harris County, Texas for Flood Plain Management	All development occurring within the floodplain of unincorporated Harris County requires a permit from Harris County; provide land use controls necessary to qualify unincorporated areas of Harris County for flood insurance under requirements of the National Flood Insurance Act of 1968, as amended, to protect human life and health (Harris County 2007).	Floodplain management is addressed under the Federal requirements for floodplains.

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[5] A CNRA is a coastal wetland, oyster reef, hard substrate reef, submerged aquatic vegetation, tidal sand, or mud flat.

[6] Harris County authorization is based upon Texas Local Government Code Section 240.901, as amended; Texas Transportation Code Sections 251.001 - 251.059 and Sections 254.001 - 254.019, as amended; the Harris County Road Law, as amended; and the Flood Control and Insurance Act, Subchapter I of Chapter 16 of the Texas Water Code, as amended. This is included here for discussion without admitting that these local requirements constitute ARARs since local requirements are not included within the definition of ARARs in the NCP. See 40 CFR Section 300.5.

Table 3-1
Applicable or Relevant and Appropriate Requirements Summary

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Table 4-1
Summary of Quantities and Durations

	Alternative 1 No Further Action	Alternative 2 Institutional Controls (IC) and Monitored Natural Recovery (MNR)	Alternative 3 IC, MNR, and Permanent Cap	Alternative 4 IC, MNR, Permanent Cap, and Partial S/S Treatment	Alernative 5 IC, MNR, Permanent Cap, and Partial Removal	Alernative 6 IC, MNR, and Full Removal
Site Preparation						
TCRA Armor Rock Removal (cy)	N/A	N/A	0	6,900	6,900	24,000
Duration (days)	N/A	N/A	0	12	12	40
Sheetpile Install/Remove (lf)	N/A	N/A	0	1,400	0	0
Duration (days)	N/A	N/A	0	70	0	0
Construction of a Permanent Cap						
Armor Rock Placement (cy)	N/A	N/A	3,400	3,400	3,400	0
Duration (days)	N/A	N/A	23	23	23	0
Treatment						
Sediment Solidification (cy)	N/A	N/A	0	53,300	0	0
Duration (days)	N/A	N/A	0	178	0	0
Removal						
Dredging (cy)	N/A	N/A	0	0	53,300	208,300
Residuals Cover/Backfill (cy)	N/A	N/A	0	0	53,300	15,900
Duration (days)	N/A	N/A	0	0	173	292
Capping						
TCRA Armor Rock Replacement (cy)	N/A	N/A	0	6,900	6,900	0
Duration (days)	N/A	N/A	0	46	46	0
TOTAL DURATION (months)	**N/A**	**N/A**	**2**	**15**	**12**	**16**

Notes:
1. All quantities include a 20 percent contingency
2. Quantities shown in cubic yards (cy) or linear feet (lf)
3. Durations assume a 22 day month, rounded up
4. Production rates assumed as follows:
    a. Armor Rock Removal - 600 cy/day
    b. Sheetpile Install/Remove - 20 lf/day
    c. Armor Rock Placement - 150 cy/day
    d. Solidification - 300 cy/day
    e. Dredging - 800 cy/day
    f. Residuals Cover/Backfill - 500 cy/day

Table 4-2
Summary of Construction Emissions Factors

	Alternative 1 No Further Action	Alternative 2 Institutional Controls (IC) and Monitored Natural Recovery (MNR)	Alternative 3 IC, MNR, and Permanent Cap	Alternative 4 IC, MNR, Permanent Cap, and Partial S/S Treatment	Alernative 5 IC, MNR, Permanent Cap, and Partial Removal	Alernative 6 IC, MNR, and Full Removal
Site Preparation						
Heavy Equipment Hours	N/A	N/A	0	2,450	350	2,000
Truck Trips	N/A	N/A	0	570	550	1,800
Construction of a Permanent Cap						
Heavy Equipment Hours	N/A	N/A	750	750	750	0
Truck Trips	N/A	N/A	260	260	260	0
Treatment						
Heavy Equipment Hours	N/A	N/A	0	1,800	0	0
Truck Trips	N/A	N/A	0	250	0	0
Removal						
Heavy Equipment Hours	N/A	N/A	0	0	5,050	13,500
Truck Trips	N/A	N/A	0	0	8,000	16,800
Capping						
Heavy Equipment Hours	N/A	N/A	0	800	800	0
Truck Trips	N/A	N/A	0	520	520	0
TOTAL HEAVY EQUIPMENT HOURS	**N/A**	**N/A**	**750**	**5,800**	**6,950**	**15,500**
TOTAL TRUCK TRIPS	**N/A**	**N/A**	**260**	**1,600**	**9,330**	**18,600**
NORMALIZED EQUIPMENT HOURS			**1.0**	**7.7**	**9.3**	**20.7**
NORMALIZED TRUCK TRIPS			**1.0**	**6.2**	**35.9**	**71.5**

Notes:

1. Equipment hours and truck trips based on durations and quantities in Table 4-1
2. Equipment hours assume 10 hour day and 80% up-time for each piece of equipment
3. Truck trips assume a capacity of 20 tons per truck
4. Site preparation includes TCRA cap rock removal and sheet pile installation. Additional site preparation activities would add to equipment hours and truck trips but were not included as a simplifying assumption
5. Removal includes placement of backfill/residuals management cover

Table 4-3
Summary of Worker Risk Factors

	Alternative 1 No Further Action	Alternative 2 Institutional Controls (IC) and Monitored Natural Recovery (MNR)	Alternative 3 IC, MNR, and Permanent Cap	Alternative 4 IC, MNR, Permanent Cap, and Partial S/S Treatment	Alernative 5 IC, MNR, Permanent Cap, and Partial Removal	Alernative 6 IC, MNR, and Full Removal
Site Preparation						
Non Fatal Injuries	N/A	N/A	0.000	0.478	0.068	0.390
Fatal Injuries	N/A	N/A	0.0000	0.0019	0.0003	0.0016
Construction of a Permanent Cap						
Non Fatal Injuries	N/A	N/A	0.146	0.146	0.146	0.000
Fatal Injuries	N/A	N/A	0.0006	0.0006	0.0006	0.0000
Treatment						
Non Fatal Injuries	N/A	N/A	0.000	0.351	0.000	0.000
Fatal Injuries	N/A	N/A	0.0000	0.0014	0.0000	0.0000
Removal						
Non Fatal Injuries	N/A	N/A	0.000	0.000	0.985	2.633
Fatal Injuries	N/A	N/A	0.0000	0.0000	0.0040	0.0106
Capping						
Non Fatal Injuries	N/A	N/A	0.000	0.156	0.156	0.000
Fatal Injuries	N/A	N/A	0.0000	0.0006	0.0006	0.0000
TOTAL NON-FATAL INJURIES	**N/A**	**N/A**	**0.146**	**1.131**	**1.355**	**3.023**
TOTAL FATAL INJURIES	**N/A**	**N/A**	**0.0006**	**0.0046**	**0.0055**	**0.0122**
NORMALIZED INJURY RATE			**1.0**	**7.7**	**9.3**	**20.7**

Notes:

1. Incident Rates based on data from U.S. Department of Labor (USDL), Bureau of Labor Statistics (USDL 2011)
2. Non-fatal injury estimate based on a rate of 3.9 per 200,000 work hours (NAICS code 23 - construction)
3. Fatal injury estimate based on a rate of 15.7 per 200,000,000 work hours (construction laborer)
4. Total employee work hours estimated based on equipment work hours (Table 4-2) and assuming a crew of 10: 5 workers at the staging area and 5 workers at the work site (3 operators + 2 support workers at each location)

USDL 2011. U.S. Department of Labor, Bureau of Labor Statistics, OSHA Recordable Case Rates and Census of Fatal Occupational Injuries, 2011

Table 5-1
Detailed Evaluation of Remedial Alternatives

	Alternative 1 **No Further Action**	**Alternative 2** **Institutional Controls (IC) and Monitored Natural Recovery (MNR)**	**Alternative 3** **IC, MNR, and Permanent Cap**	**Alternative 4** **IC, MNR, Permanent Cap, and Partial S/S Treatment**	**Alternative 5** **IC, MNR, Permanent Cap, and Partial Removal**	**Alternative 6** **IC, MNR, and Full Removal**
Threshold Criteria						
Overall Protection	Meets	Meets	Meets	Meets	Meets	Meets
Compliance with ARARs	Meets	Meets	Meets	Meets	Meets	Meets
Balancing Criteria						
Long-Term Effectiveness	• TCRA cap has effectively prevented exposure of ecological and human receptors and requires long-term operations, monitoring and maintenance (OMM) • Natural recovery of sediments within the preliminary Site boundary will continue to provide additional reduction in exposure to dioxins and furans in surface sediments	• Same as Alternative 1 plus: • ICs protect the integrity of the TCRA cap, alert potential future property owners about subsurface risk in subsurface sediment, and control exposure to contaminated subsurface soil through use-restrictions on properties south of I-10	• Same as Alternative 2 plus: • Construction of a permanent cap would provide additional reliability for the long-term performance	• Same as Alternative 3 plus: • S/S of selected sediment would provide redundant mobility controls (in addition to cap)	• Same as Alternative 3 plus: • Removal of selected sediment would eliminate the long-term potential of mobilizing COCs adsorbed to these sediments, which are already effectively contained by the TCRA cap	• Same as Alternative 2 plus: • Removal of sediment from footprint of TCRA cap to the PCL for hypothetical recreational visitors would eliminate the long-term potential of mobilizing COCs adsorbed to these sediments, which are already effectively contained by the TCRA cap • Residuals cover would be required to manage sediment left behind as a result of dredging
Reduction of TMV	• Mobility already reduced through treatment during the TCRA • Dioxin and pulp waste are not mobile in the environment • No additional reduction proposed	• Same as Alternative 1	• Mobility already reduced through treatment during TCRA • Dioxin and pulp waste are not mobile in the environment • Additional potential mobility reduction achieved by construction of a permanent cap	• Same as Alternative 3 plus: • Additional mobility reduction through S/S	• Post-removal dewatering would reduce the mobility of COCs through the addition of amendments to facilitate transportation and disposal • Sediment might need to be incinerated as part of the disposal process, which would remove organic COCs	• Same as Alternative 5
Short-Term Effectiveness	• Achieve protection immediately • No water quality impacts associated with implementation • No sediment quality impacts associated with implementation • No tissue impacts associated with implementation	• Same as Alternative 1	• Achieve protection upon completion of implementation • Minimal water quality impacts from turbidity during rock placement for construction of a permanent cap. • No sediment quality impacts associated with implementation	• Achieve protection upon completion of implementation • Water quality impacts during cap removal • Water quality impacts during sheetpile installation and removal • Potential for sheetpile to drive contamination deeper into subgrade	• Achieve protection upon completion of implementation • Water quality impacts during cap removal • Water quality impacts from losses through turbidity barriers • Minimal water quality impacts from turbidity during backfilling and cap	• Achieve protection upon completion of implementation • Water quality impacts during cap removal • Water quality impacts from losses through turbidity barriers • Minimal water quality impacts from turbidity during backfilling and cap

Table 5-1
Detailed Evaluation of Remedial Alternatives

	Alternative 1 No Further Action	Alternative 2 Institutional Controls (IC) and Monitored Natural Recovery (MNR)	Alternative 3 IC, MNR, and Permanent Cap	Alternative 4 IC, MNR, Permanent Cap, and Partial S/S Treatment	Alternative 5 IC, MNR, Permanent Cap, and Partial Removal	Alternative 6 IC, MNR, and Full Removal
	• No worker safety risk • No air emissions from construction • No traffic impacts from construction		• No tissue impacts associated with implementation • 0.15 estimated construction worker injuries • 0.0006 estimated construction worker fatalities • Air emissions, greenhouse gas, particulate matter and ozone generation from 750 hours of equipment operations • Air emissions, greenhouse gas, particulate matter, ozone generation and traffic impacts from 260 truck trips	• Water quality impacts from losses through sheetpile gaps • Minimal water quality impacts from turbidity during backfilling and cap replacement • Minimal water quality impacts from turbidity during rock placement for construction of a permanent cap. • Sediment quality impacts from losses through sheet pile gaps • Tissue impacts from water column releases during construction • 1.1 estimated construction worker injuries • 0.005 estimated construction worker fatalities • Air emissions, greenhouse gas, particulate matter and ozone generation from 5,800 hours of equipment operations • Air emissions, greenhouse gas, particulate matter, ozone generation and traffic impacts from 1,600 truck trips • Potential air emissions of particulate matter during stabilization operations	replacement • Minimal water quality impacts from turbidity during rock placement for construction of a permanent cap. • Sediment quality impacts from dredging residuals • Tissue impacts from water column releases during construction • 1.4 estimated construction worker injuries • 0.006 estimated construction worker fatalities • Air emissions, greenhouse gas, particulate matter and ozone generation from 6,950 hours of equipment operations • Air emissions, greenhouse gas, particulate matter, ozone generation and traffic impacts from 9,330 truck trips • Potential air emissions of particulate matter during sediment dewatering, if amendments are used • Air emissions from incineration operations, if used • Risk of public exposure to Site materials during off-site transport due to accidents or spills	replacement • Minimal water quality impacts from turbidity during rock placement for construction of a permanent cap. • Sediment quality impacts from dredging residuals • Tissue impacts from water column releases during construction • 3.0 estimated construction worker injuries • 0.01 estimated construction worker fatalities • Air emissions, greenhouse gas, particulate matter and ozone generation from 15,500 hours of equipment operations • Air emissions, greenhouse gas, particulate matter, ozone generation and traffic impacts from 18,600 truck trips • Potential air emissions of particulate matter during sediment dewatering, if amendments are used • Air emissions from incineration operations, if used • Risk of public exposure to Site materials during off-site transport due to accidents or spills

Table 5-1
Detailed Evaluation of Remedial Alternatives

	Alternative 1 **No Further Action**	**Alternative 2** **Institutional Controls (IC) and Monitored Natural Recovery (MNR)**	**Alternative 3** **IC, MNR, and Permanent Cap**	**Alternative 4** **IC, MNR, Permanent Cap, and Partial S/S Treatment**	**Alternative 5** **IC, MNR, Permanent Cap, and Partial Removal**	**Alternative 6** **IC, MNR, and Full Removal**
Implementability	• Minor implementability issues associated with ongoing OMM of TCRA cap	• Property owners may object to land-use restrictions	• Same as Alternative 2 plus: • Site access limited as demonstrated during TCRA construction • Equipment size restricted by low bridge clearance on river • On-site staging area limited • Materials and equipment readily available for construction of a permanent cap. • Construction of a permanent cap placement techniques successfully demonstrated during TCRA construction	• Same as Alternative 3 plus: • Requires partial removal of TCRA cap, decontamination of those materials, and possible disposal • Isolation and dewatering of the treatment or removal area is a construction challenge, particularly if elevated water level occurs during construction • S/S treatment of materials with very high water content is more difficult to implement and less certain, particularly if Site is flooded during implementation	• Same as Alternative 3 plus: • Require partial removal of TCRA cap, decontamination of those materials, and possible disposal • Engineering controls such as silt curtains are difficult to implement and maintain in a flowing river, as demonstrated during TCRA construction • Locating a nearby facility that can accommodate staging, offloading and sediment processing needed for the excavated material, and for the expected is considered a challenge	• Same as Alternative 5 plus: • Volume of material is significantly greater, multiplying implementability challenges • Locating a nearby facility that can accommodate staging, offloading and sediment processing needed for the large volume of excavated material, and for the expected duration of the project, is considered a significant challenge • Finding off-site disposal for high volume of dioxin/furan contaminated soil/sediment considered to be a challenge • Constriction of a permanent cap considerations discussed for Alternative 3 are not applicable
Cost	$1.6M	$1.6M	$2.9M	$11.2M	$24 to $118M	$104 to $636M
Modifying Criteria						
State Acceptance	TBD	TBD	TBD	TBD	TBD	TBD
Community Acceptance	TBD	TBD	TBD	TBD	TBD	TBD

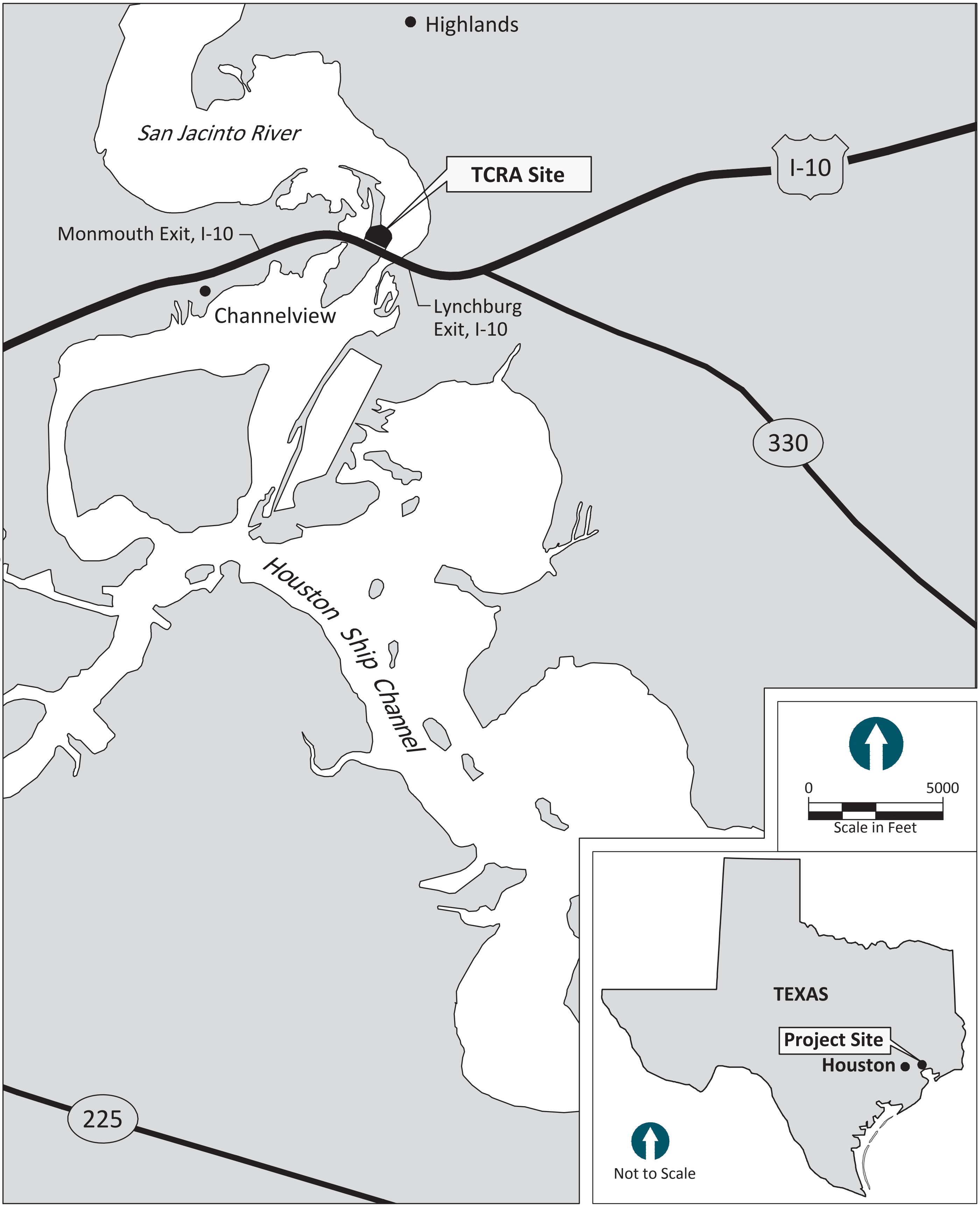
Notes:

ARARs - Applicable or Relevant and Appropriate Requirements
COCs - chemicals of concern
IC - Institutional Controls
MNR - Monitored Natural Recovery
OMM - Operations, Monitoring, and Maintenance
PCL - Protective Concentration Level
S/S - solidification/stabilization
TBD – To Be Determined
TCRA – Time Critical Removal Action
TMV - toxicity, mobility, or volume

Table 5-2
Release Case Studies

Project	Environmental Dredging Activity	BMPs	Source of Release Estimate	Contaminant Mass Released	Primary Reference
1995 Grasse River NTCRA Pilot Study	3,000 cy of sediment and debris removed using hydraulic dredge for sediments	Dredging operation BMPs and silt curtains	Caged fish monitoring	Adjacent fish tissue concentrations increased 50x; 0.9 km downstream fish tissue concentrations increased 5x	"Non-Time Critical Removal Action (NTCRA) Pilot Dredging in the Grasse River" presentation to the NAS Panel on Risk-management Strategy for PCB-Contaminated Sediments. November 8, 1999.
1999-2000 Fox River SMU 56/57 Dredging Pilot Study	82,000 cy removed using hydraulic cutterhead dredge	Dredging operation BMPs and silt curtains	Water quality monitoring data collected 100 to 200 feet downstream of the dredge, outside of silt curtains	Average **2.2%** of dredged PCB mass released into water column, with roughly 30% as dissolved phase PCBs	Steuer, J.J., 2000. A mass-balance approach for assessing PCB movement during remediation of a PCB-contaminated deposit on the Fox River, Wisconsin. USGS Water-Resources Investigations Report 00-4245.
2004 Duwamish/ Diagonal Early Action	70,000 cy removed using clamshell mechanical dredge	Dredging operation BMPs	Fate/transport and food web modeling to simulate measured fish tissue PCB increases during and after dredging	Fish tissue increases simulated assuming an average **3%** (range: 1 to 6%) of dredged PCB mass released and available for bioaccumulation	Stern, J. H., 2007. Temporal effects of dredge-related releases on fish tissue concentrations: Implications to achieving net risk reduction. SETAC North America 28th Annual Meeting, Nov. 2007, Milwaukee, WI.
2005 Grasse River Remedial Options Pilot Study	25,000 cy removed using hydraulic cutterhead dredge	Dredging operation BMPs and silt curtains	Water quality monitoring data collected more than 2,000 feet downstream of the dredge, outside of silt curtains	Average **3%** of dredged PCB mass released into water column, with more than 50% as dissolved phase PCBs	Connolly J.P., J.D. Quadrini , and L.J. McShea, 2007. Overview of the 2005 Grasse River Remedial Options Pilot Study. In: Proceedings, Remediation of Contaminated Sediments—2007. Savannah, GA. Columbus (OH): Battelle.
2005 Lower Passaic River Dredging Pilot Study	4,000 cy removed using clamshell mechanical dredge	Dredging operation BMPs and rinse tank	Water quality monitoring data collected 400 feet downstream of the dredge over the 5 day dredging event	Average **3 to 4%** (range: 1 to 6%) of dredged dioxin mass released into water column	Lower Passaic River Restoration Project Team, 2009. Revision and Updates to the Environmental Dredging Pilot Study. Project Delivery Team Meeting. March 2009.
2009 Hudson River Phase I Dredging	280,000 cy removed using clamshell mechanical dredge	Dredging operation BMPs and silt curtains	Water quality monitoring data collected more than 10,000 feet downstream of the dredge, outside of silt curtains	Average **3 to 4%** of dredged PCB mass released into water column, with 70 to 90% as dissolved phase PCBs	Anchor QEA and Arcadis, 2010. Phase 1 Evaluation Report: Hudson River PCBs Superfund Site. Report prepared for General Electric, Albany, New York. March 2010.

FIGURES



K:\Jobs\090557-San Jacinto\090557-01 - San Jacinto\09055701-RP-049.dwg FIG 1-1 FS

Jun 04, 2013 10:59am heriksen

ANCHOR QEA integral consulting inc.

DRAFT

Figure 1-1
Vicinity Map
Feasibility Study
San Jacinto River Waste Pits Superfund Site

NOTES:

1. Designation of the Upland Sand Separation Area is intended to be a general reference to areas in which such activities are believed to have taken place based on a review of aerial photography from 1998 through 2002.
2. Aerial Imagery: Copyright Microsoft Bing Maps, 2010.
3. Hog Island location source: Google Earth, 2011.

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Figure 1-2
USEPA's Preliminary Site Perimeter and Surrounding Area
Feasibility Study
San Jacinto River Waste Pits Superfund Site

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USEPA's Preliminary Site Perimeter

Limit of TCRA Cap

Tax Parcel Boundary

Figure 2-1
Land Use in the Vicinity of USEPA's Preliminary Site Perimeter
Feasibility Study
San Jacinto River Waste Pits Superfund Site

0 0.5
Scale in Miles

FEATURE SOURCES:
Land Use: Modified from Houston-Galveston Area Council*
Parcel Boundaries: Harris County Appraisal District

*Modifications to land use within USEPA's Preliminary Site Perimeter to show reasonably anticipated future land use where appropriate.

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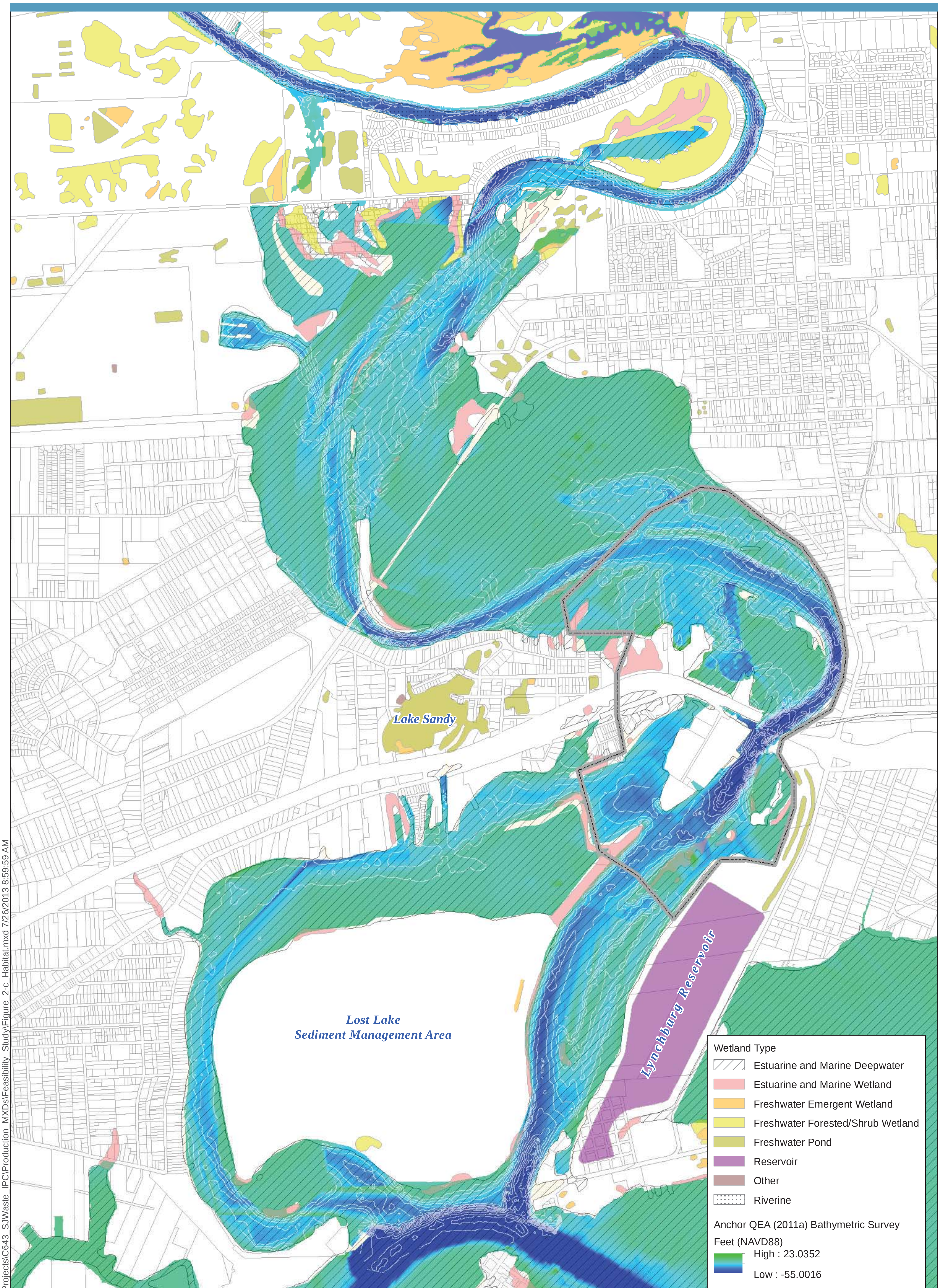

USEPA's Preliminary Site Perimeter
1-Meter 1995 Bathymetric Contour
Parcel Boundary

Figure 2-2
Habitats in the Vicinity of USEPA's Preliminary Site Perimeter
Feasibility Study
San Jacinto River Waste Pits Superfund Site

0 0.5
Miles

FEATURE SOURCES:
Bathymetry and Contours: Anchor QEA (2011a)
Wetlands: U.S. Fish and Wildlife Service.
Parcel Boundaries: Harris County Appraisal District.

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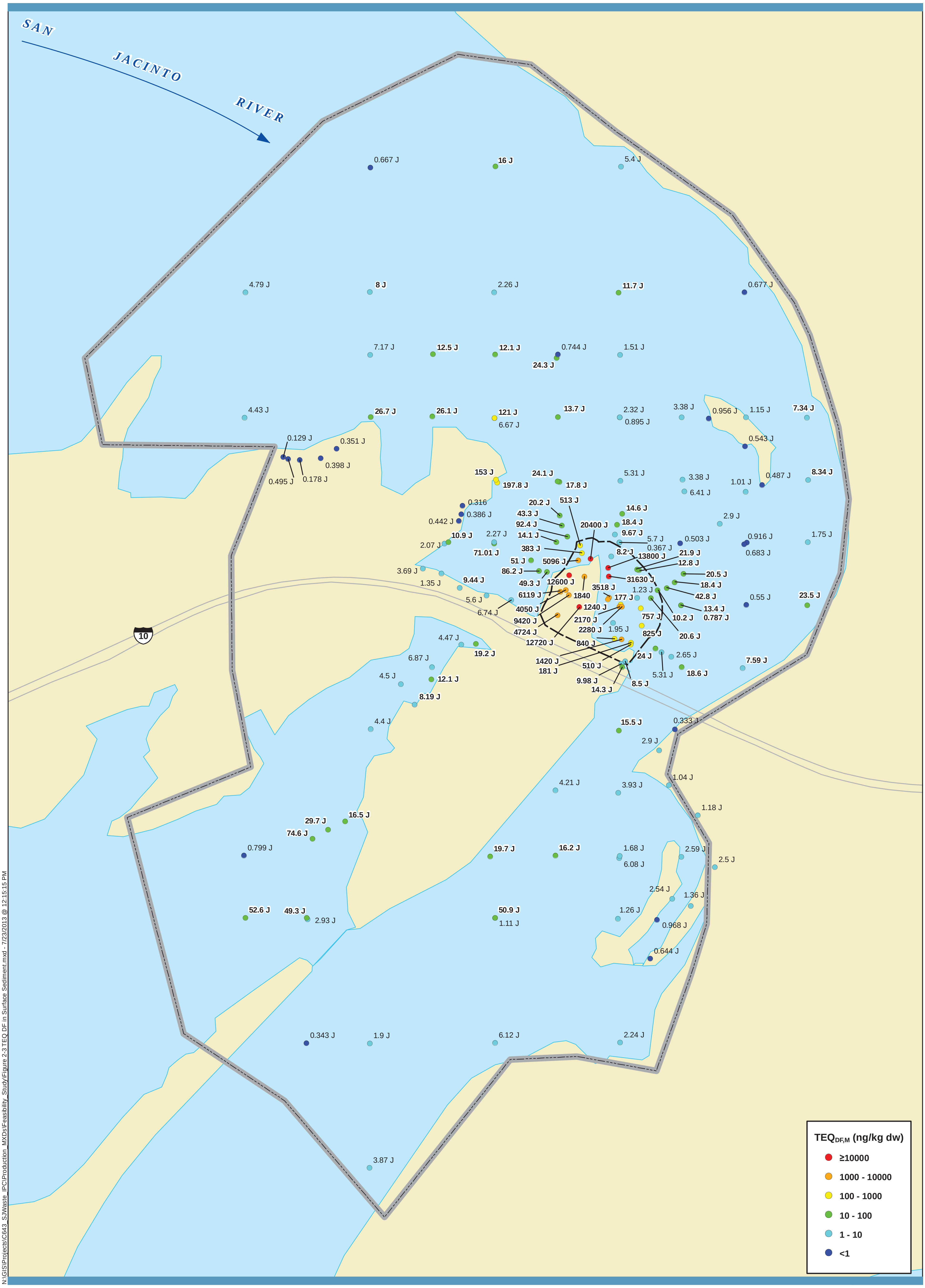

N:\GIS\Projects\C643_SJWaste_IPC\Production_MXDs\Feasibility_Study\Figure 2-3 TEQ DF in Surface Sediment.mxd - 7/23/2013 @ 12:15:15 PM

ANCHOR QEA

integral consulting inc

0 800

Feet

USEPA's Preliminary Site Perimeter

Limit of TCRA Cap

○ Surface Sediment Sample Location

Notes:

$TEQ_{DF,M}$ = Toxicity equivalent for 2,3,7,8-TCDD calculated for dioxins and furans using mammalian TEFs from van den Berg et al. (2006) (nondetect = 1/2 detection limit)

J = Estimated. One or more congeners used to calculate the $TEQ_{DF,M}$ was not detected.

Concentrations in bold indicate values above reference envelope value (REV); REV = 7.2 ng/kg dw

Figure 2-3

$TEQ_{DF,M}$ Concentrations in Surface Sediment

Feasibility Study

San Jacinto River Waste Pits Superfund Site

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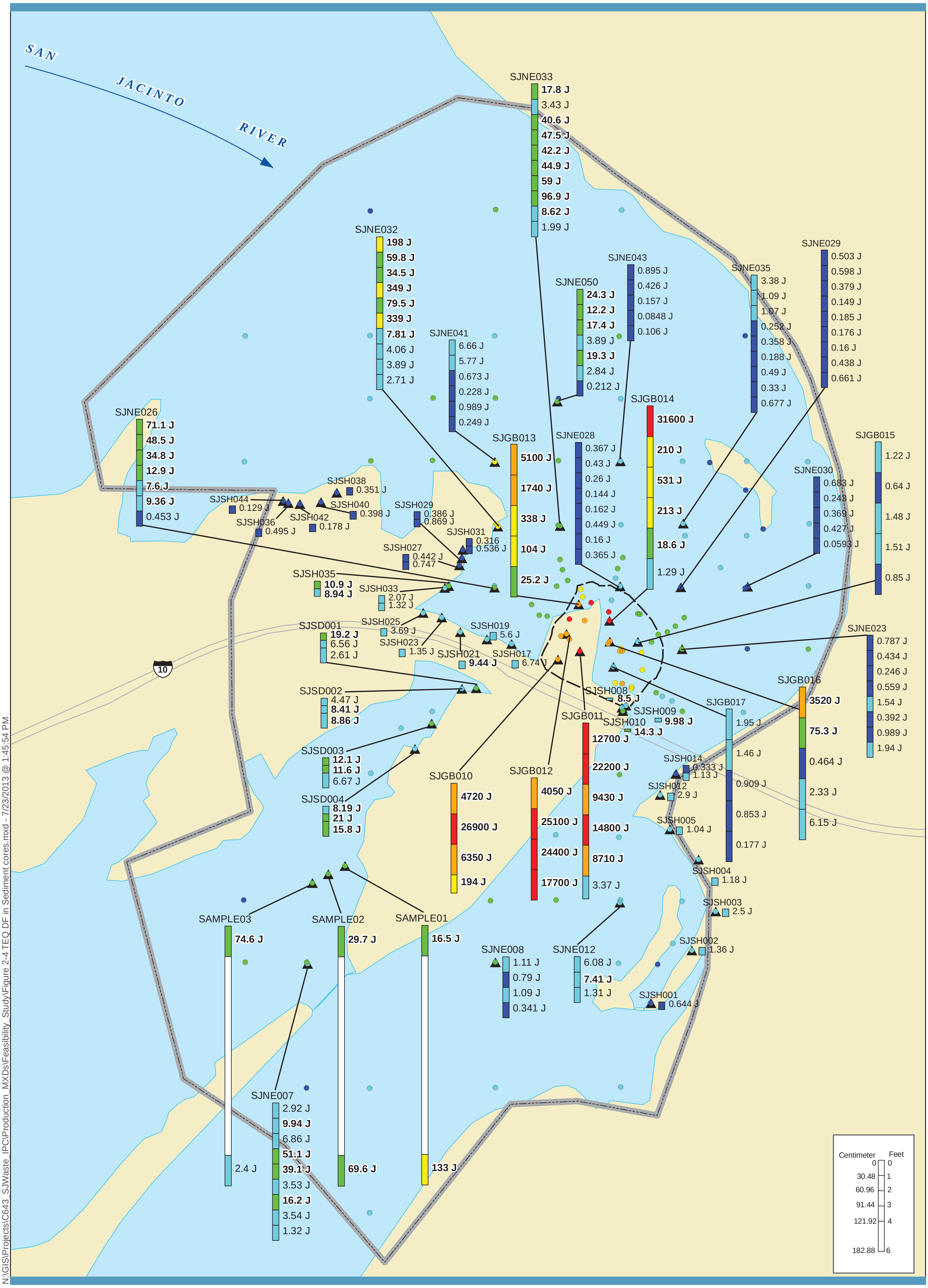

ANCHOR QEA

integral consulting inc

0 800
Scale in Feet

USEPA's Preliminary Site Perimeter

Limit of TCRA Cap

Core Location

Surface Sediment Sample Location

$TEQ_{DF,M}$ (ng/kg dw)

Cores

- ≥10000
- 1000 - 10000
- 100 - 1000
- 10 - 100
- 1 - 10
- <1
- No analysis

Notes:

$TEQ_{DF,M}$ = Toxicity equivalent for 2,3,7,8-TCDD calculated for dioxins and furans using mammalian TEFs from van den Berg et al. (2006) (nondetect = 1/2 detection limit)

J = Estimated. One or more congeners used to calculate the $TEQ_{DF,M}$ was not detected.

Concentrations in bold indicate values above reference envelope value (REV); REV= 7.2 ng/kg dw

Figure 2-4

$TEQ_{DF,M}$ Concentrations in Sediment Cores

Feasibility Study

San Jacinto River Waste Pits Superfund Site

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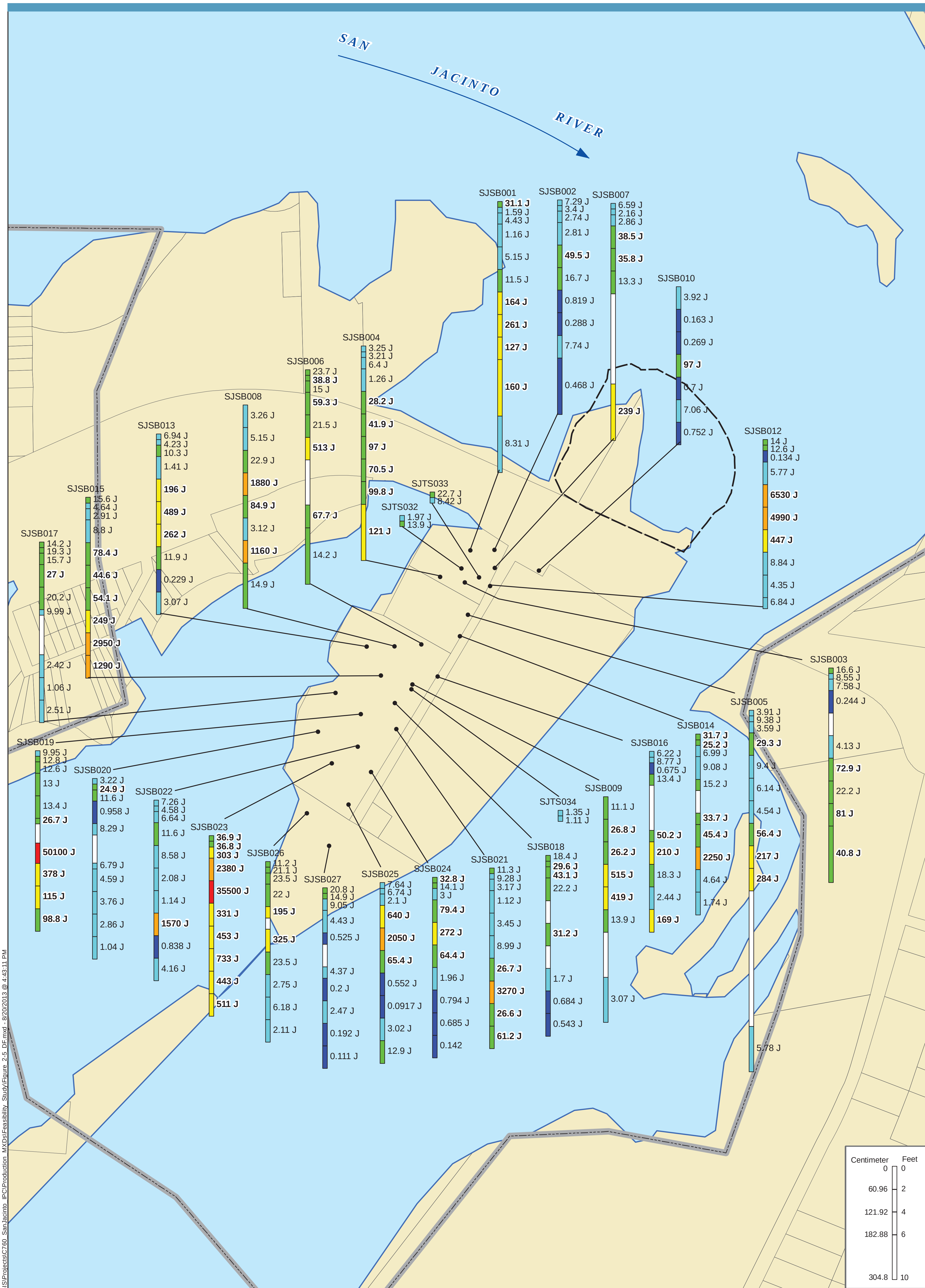

ANCHOR QEA

integral consulting inc

0 800
Feet

USEPA's Preliminary Site Perimeter

Limit of TCRA Cap

Soil Boring Location

Notes:
$TEQ_{DF,M}$ = Toxicity equivalent for dioxins and furans using mammalian TEFs from van den Berg et al. (2006) (nondetect =1/2 detection limit)

J = Estimated, One or more congeners used to calculate the $TEQ_{DF,M}$ was not detected

Concentrations in bold indicate values above reference envelope value (REV); REV= 24.3 ng/kg dw

FEATURE SOURCES:
Parcel Boundaries: Harris County Appraisal District
Hydrology: Harris County Flood Control District

$TEQ_{DF,M}$ (ng/kg dw)

Cores

- ≥10000
- 1000 - 10000
- 100 - 1000
- 10 - 100
- 1 - 10
- <1
- No analysis

Figure 2-5
$TEQ_{DF,M}$ Concentrations in Soil South of I-10
Feasibility Study
San Jacinto River Waste Pits Superfund Site

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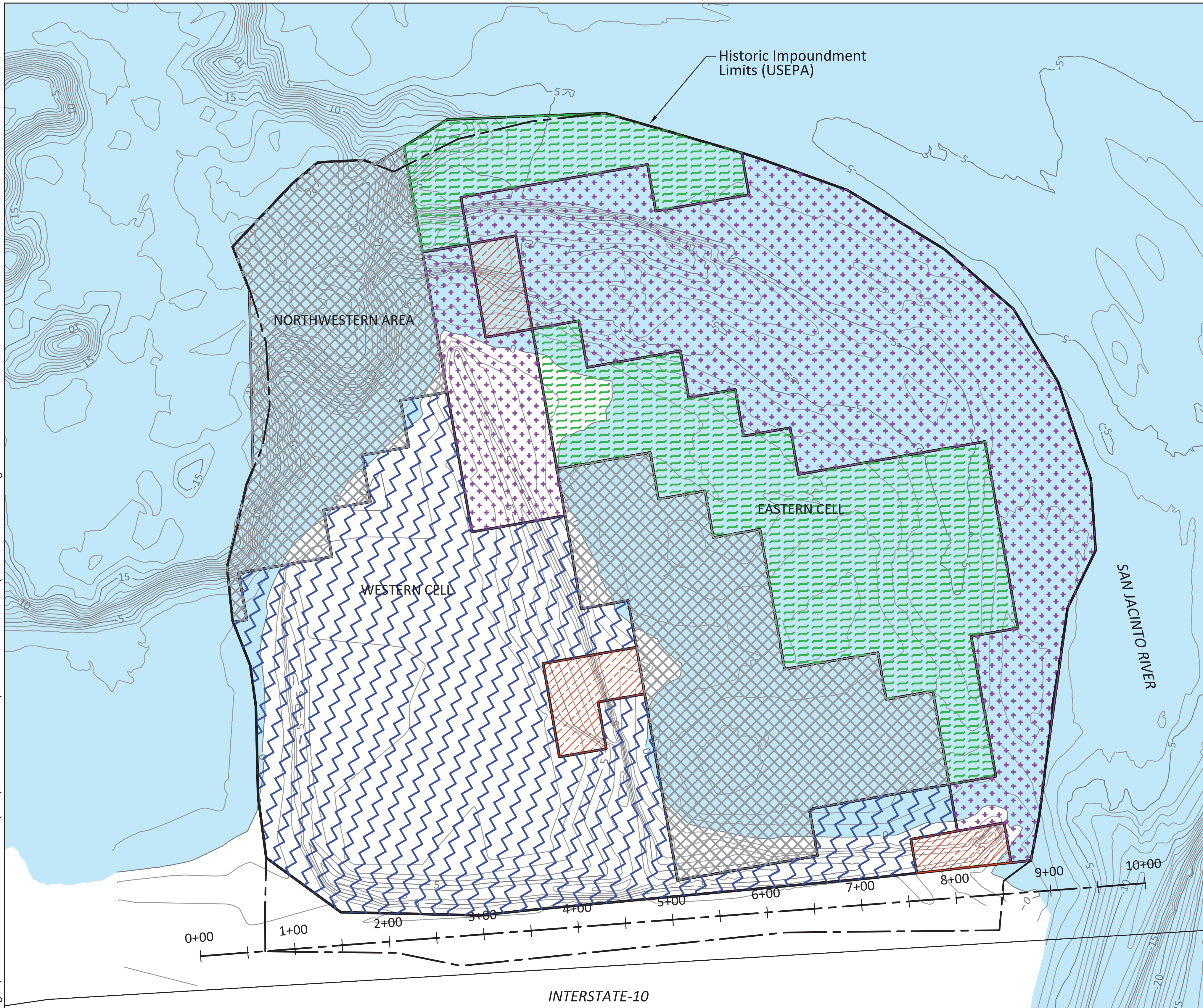

LEGEND:

- Pre-Construction Contour, 6/12/10 (1-foot interval)
- Historic Impoundment Limit (USEPA)
- Armored Cap $A_{(P)}$ (Recycled)
- Armored Cap $B/C_{(P)}$ (Recycled)
- Armored Cap $C_{(N)}$ (Natural)
- Armored Cap $D_{(N)}$ (Natural)
- Armored Cap $D_{(N)}$ (Natural) (24"-Thick)
- Surveyed Extent of Installed Geotextile and Geomembrane in Western Cell
- Approximate Water Surface Elevation (0 feet NAVD88)

HORIZONTAL DATUM: Texas South Central, NAD83. US Survey Feet.

VERTICAL DATUM: NAVD88.

0 120
Scale in Feet

Aug 29, 2013 8:45am dholmer K:\Jobs\090557-San Jacinto\090557-01 - San Jacinto\090557-01-RP-112.dwg FIG 2-6 FS

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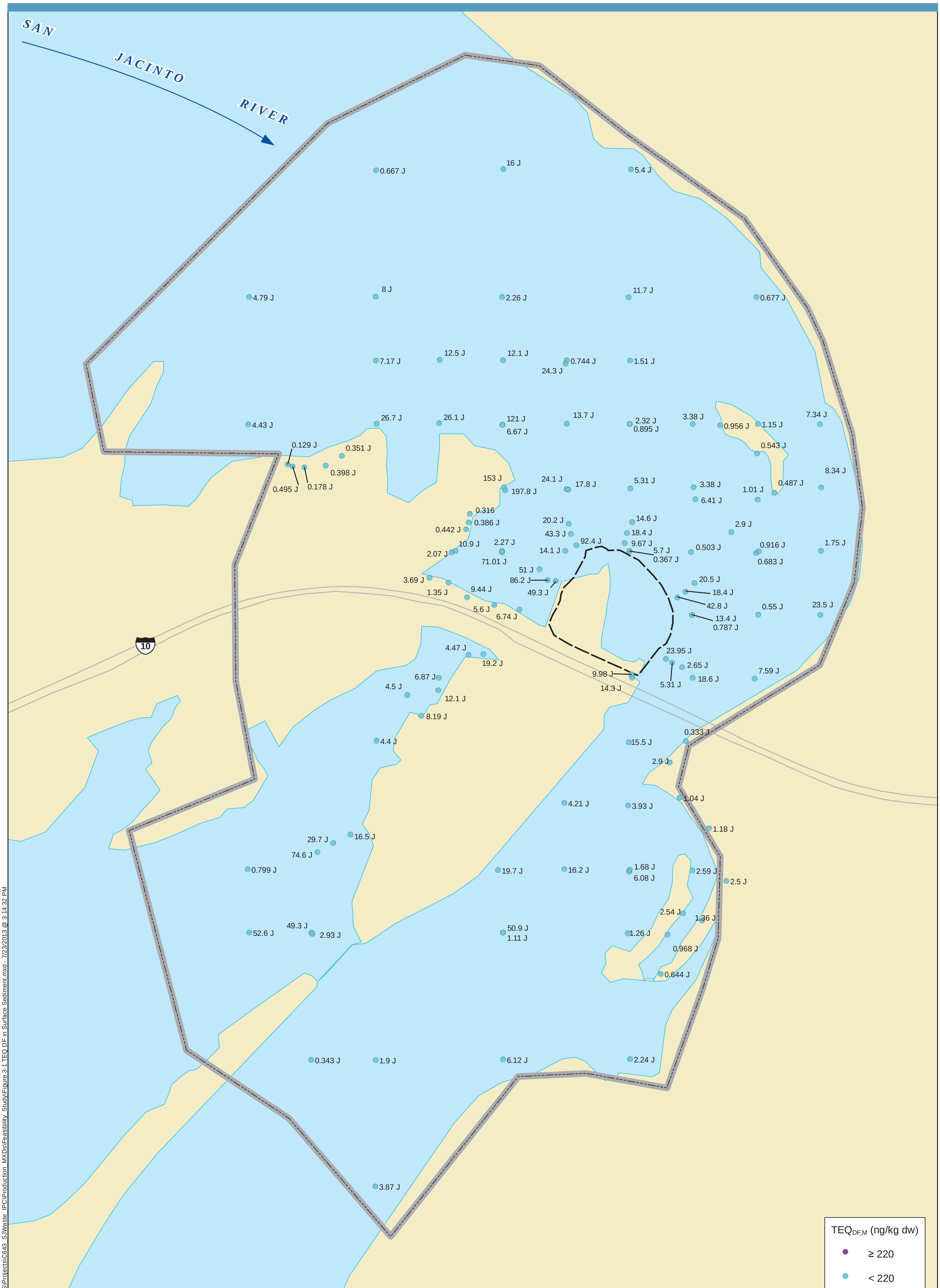
Figure 2-6
TCRA Cap As-Built Drawing
Feasibility Study
San Jacinto River Waste Pits Superfund Site



N:\GIS\Projects\C643_SJWaste_IPC\Production_MXDs\Feasibility_Study\Figure 3-1 TEQ DF in Surface Sediment.mxd - 7/23/2013 @ 3:14:32 PM

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integral consulting inc

0 800

Feet

USEPA's Preliminary Site Perimeter

Limit of TCRA Cap

Surface Sediment Sample Location

Notes:

$TEQ_{DF,M}$ = Toxicity equivalent for 2,3,7,8-TCDD calculated for dioxins and furans using mammalian TEFs from van den Berg et al. (2006) (nondetect = 1/2 detection limit)

J = Estimated. One or more congeners used to calculate the $TEQ_{DF,M}$ was not detected.

The sediment Protective Concentration Level for a hypothetical recreational visitor for $TEQ_{DF,M}$ is 220 ng/kg dry weight.

Figure 3-1

$TEQ_{DF,M}$ Concentrations in Surface Sediment

Compared to Hypothetical Recreational Visitor PCL

Feasibility Study

San Jacinto River Waste Pits Superfund Site

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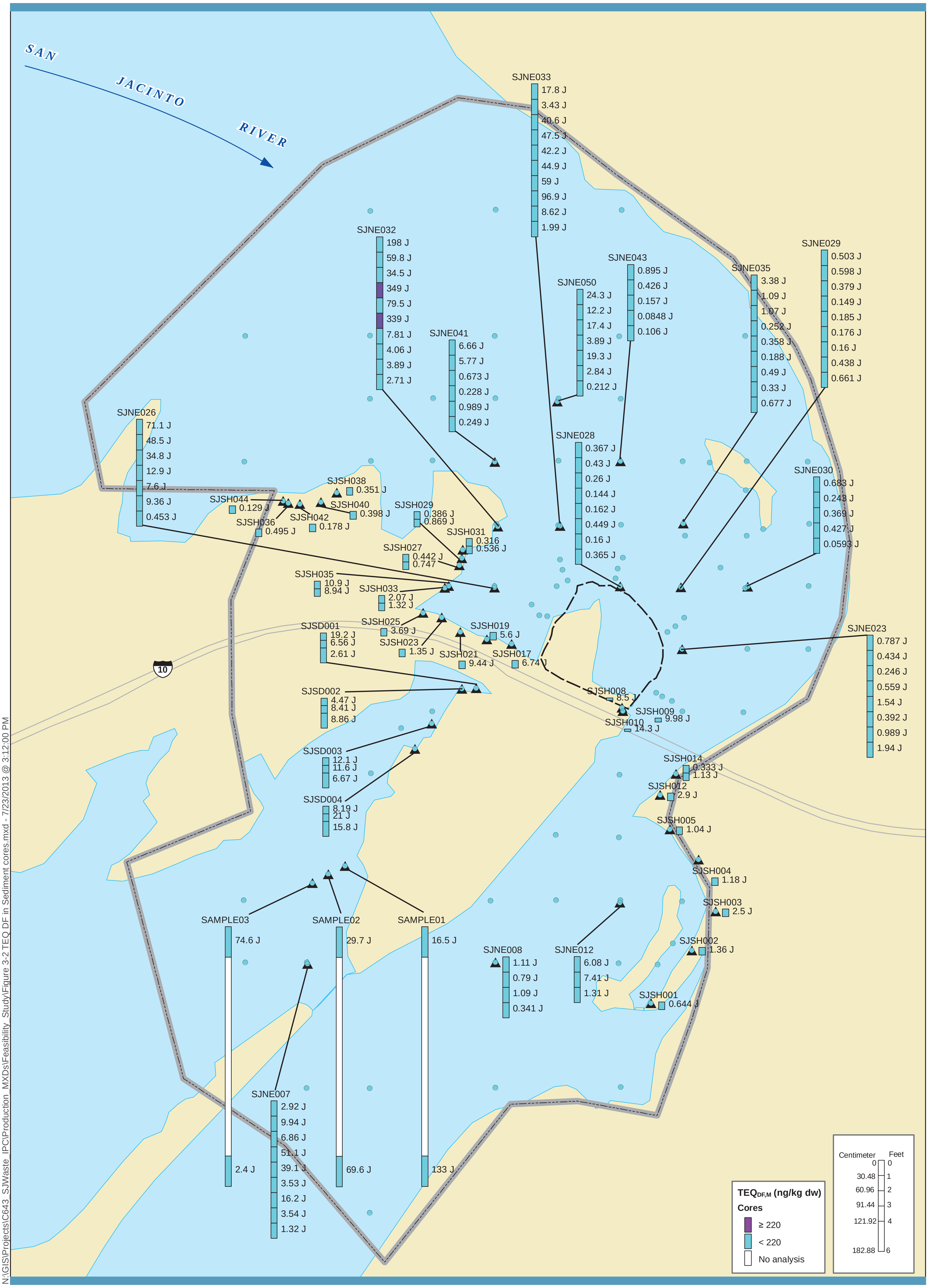

N:\GIS\Projects\C643_SJWaste_IPC\Production_MXDs\Feasibility_Study\Figure 3-2 TEQ DF in Sediment cores.mxd - 7/23/2013 @ 3:12:00 PM

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USEPA's Preliminary Site Perimeter
Limit of TCRA Cap
Core Location
Surface Sediment Sample Location

0 800
Scale in Feet

Notes:
$TEQ_{DF,M}$ = Toxicity equivalent for 2,3,7,8-TCDD calculated for dioxins and furans using mammalian TEFs from van den Berg et al. (2006) (nondetect = 1/2 detection limit)

J = Estimated. One or more congeners used to calculate the $TEQ_{DF,M}$ was not detected.

The sediment Protective Concentration Level for a hypothetical recreational visitor for $TEQ_{DF,M}$ is 220 ng/kg dry weight.

Figure 3-2
$TEQ_{DF,M}$ Concentrations in Sediment Cores Compared to Hypothetical Recreational Visitor PCL
Feasibility Study
San Jacinto River Waste Pits Superfund Site

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